ELECTRICAL ENGINEERING

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THE COVER: Bronze figure by E. Picault symbolizes deep interest of early electrical scientists. A Leyden jar is held in experimenter's hand. At his feet rest Volta's electrophorus and electrochemical battery which ushered in the new era in electrical history. First installment of story appears on page 367.

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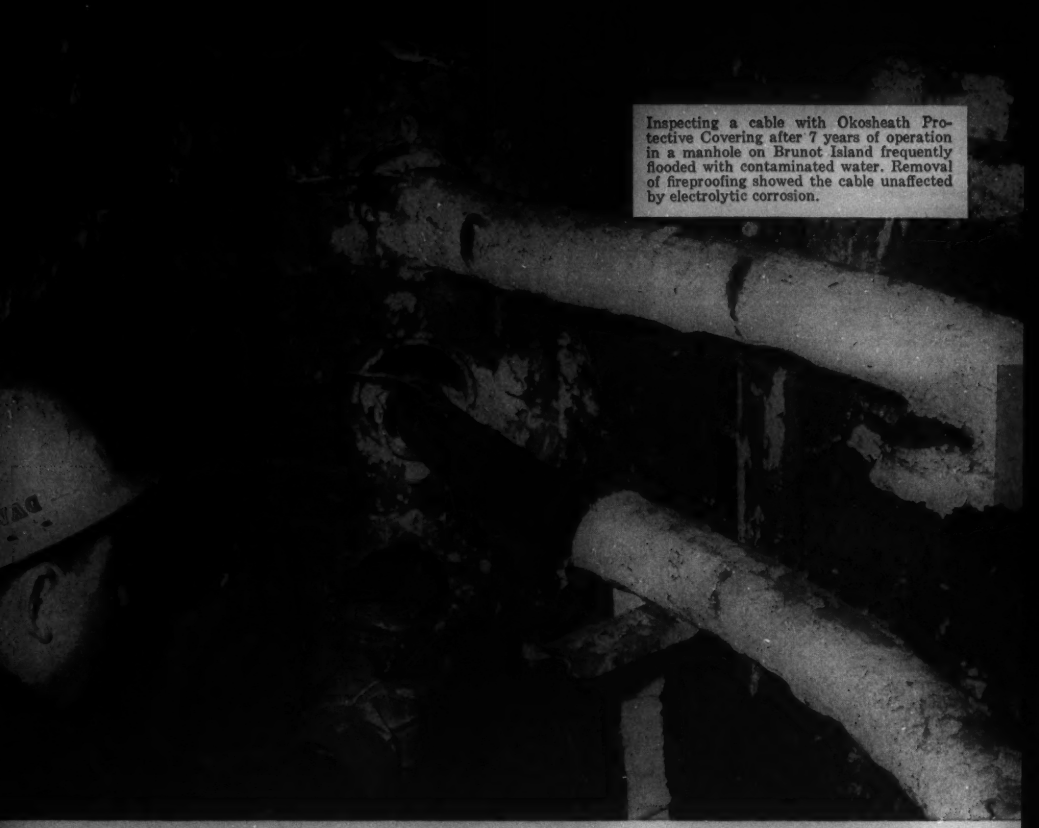

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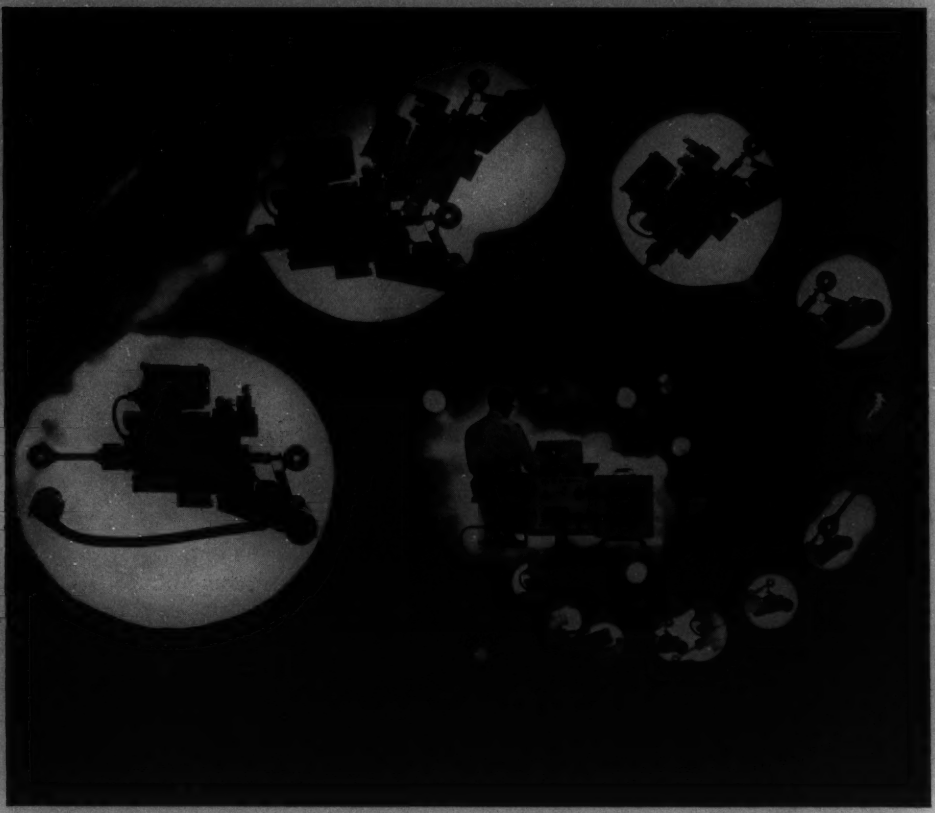

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Early Electrical Machines

BERN DIBNER
FELLOW AIEE

This is the first in a series of articles on pioneering investigations in electrical science made by men who possessed an absorbing scientific curiosity, trusting no authority no matter how renowned, subjecting everything to the supreme test of all knowledge: experimental verification. This tradition should be disseminated throughout the engineering profession so that tomorrow's engineer can meet the demands of a society that will require more than technical ability. Such eager curiosity fosters the ability to make new associations between facts already known or learned and, thus, lays the basis for the creative application of engineering knowledge and the development of tomorrow's "three dimensional engineer."

WILLIAM GILBERT (1544-1604), physician to Elizabeth I and James I, experimenter, iconoclast, and dedicated scientist, ushered in, more than anyone else before him, the procedure of experimentation that became established as "scientific method." His book "De Magnete" was the culmination of 18 years of experimentation with loadstones, induced magnets, magnetic instruments, and the meager electrical materials of his day. His work transformed the mystical, uncertain knowledge of "magnetics" and "electrics" of his time into a proved body of experimental data. His work was an answer to his own plea for experimenters to learn nature's way by watching nature perform, and thus observe the solution to the problem posed. Gilbert's book became not only the first book devoted to magnetism or electricity, but also the first book in England devoted to experimental physics. So many untruths had been passed on from writer to writer without benefit of experimental confirmation, that Gilbert, in one bold stroke, attempted to demolish the accumulation of mystery, superstition, fancy, and folly of beliefs about loadstone and amber.

Of the six "books" comprising "De Magnete" it is the second that is of special interest to us. Chapter 2 of this book is devoted to electricity, a phenomenon parallel to, but different from, magnetism, the general theme of the book.

It was also in this book that Gilbert named this attractive property "electrica" which was derived from the Greek word "elektron" for amber. The word "electricity," as such, first appeared in a book by Dr. Thomas Browne (1605-1682), entitled "Pseudodoxia Epidemica," London, 1646. Browne listed precious and common stones that did not have attractive power and included emerald, pearl, and carnelian among them.

Gilbert tried almost everything and claimed he would accept no statement on authority. He wrote "Inquisitive theologians also would throw light on the divine mysteries set beyond the range of human sense, by means of loadstone and amber; just as idle Metaphysicians, when they are setting up and teaching useless phantasms, have recourse to the loadstone as if it were a Delphick sword, an illustration always applicable to everything." He added, further, "Wherefore also such philosophy produces no fruit, because very many philosophers, making no investigation themselves, unsupported by any practical experience, idle and inert, make no progress by their records, and do not see what light they can bring to their theories; but their philosophy rests simply on the use of certain Greek words, or uncommon ones; after the manner of our gossips and barbers nowadays who make show

Hurding del. Clamp sc.

D^r. WILL^m. GILBERT,
Phyſician to Q^n. Elizabeth.
From an Original Picture in the Bodleian Library Oxford.
Pub^d. May 1796 by S. & H. Harding Pall Mall.

Partial text of "Early Electrical Machines," published by the Burndy Library.

Bern Dibner is president, Burndy Corporation, Norwalk, Conn.

of certain Latin words to an ignorant populace as the insignia of their craft, and snatch at the popular favor. For it is not only amber and jet (as they suppose) which entice small bodies; but Diamond, Sapphire, Carbuncle, Iris gem (quartz), Opal, Amethyst, Vincentina, English spar, Beryl and Crystal do the same." He then added glass, false gems made of glass, crystal, sulfur, mastic, and sealing wax. Of lesser vigor was the attraction shown by resin, rock salt, muscovy stone, and rock alum. All these substances (he termed them "electrics"), drew "not only straw and chaff, but also metals, woods, leaves, stones, earths, even water and oil, and everything subject to our senses, or that which is solid." Gilbert then proposed the design of the first electrical instrument, a "versorium" (meaning "turn-about"), a true electroscope, "three or four digits in length, resting rather lightly on its point of support after the manner of a magnetick needle . . ." A rubbed amber or gem brought up to it caused the instrument to turn, thereby demonstrating "the manifest nature of very many, both of simple substances . . . and of compositions . . ."

Gilbert also listed gems and other objects that cause no attraction even if carefully polished and rubbed. They included emerald, agate, carnelian, pearl, jasper, alabaster, coral, marble, flint, and emery. More common substances such as bone, ivory, a hardwood such as ebony, and cedar, juniper, and cypress caused no attraction. Metals, even if polished and shined, such as gold, silver, brass, or iron (including loadstone) were shown not to be electric. Further, electric substances, such as crystal, mica, and glass lost their attractive property if they were burned or roasted.

Thus, Gilbert wrote, "In all bodies in the world two causes or principles have been laid down, from which the bodies themselves were produced, matter and form. Electrical motions become strong from matter, but magnetick from form chiefly; . . ." Moist air, or a sheet of paper or linen, choked the electric virtue. On the other hand a loadstone, without friction and even under water or through planks or stone slabs, still drew magnetics. Although moisture destroyed attraction, oil, "which is light and pure," did not. "A loadstone appeals to magneticks only; towards electricks all things move." The heat of friction excited the effluvium, whereas alien heat from fire or from the sun excited no electric vigor. The best invigorators were stiff silk, rough wool rag which was as little soiled as possible, or the dry palm of a hand. At times, Gilbert contradicted his position as to whether the substance was or was not an electric.

Gilbert then examined the question of what moved what. Seeking a mechanical interpretation of the motion of light bodies toward the electrics, he decided that it was an effluvium that was exhaled from the amber or other electric by quickly rubbing it. A subtle diffusion of humor flowed from the electric to the attracted body. It was drawn to the electric within its peculiar radius and the two bodies touched and became one.

"Bodies are borne towards electricks in a straight line towards the center of the electrick; a loadstone draws a loadstone directly at the poles only, in other parts obliquely and transversely, and in this way also they adhere and hang to one another." As one of the earliest scientists to accept the doctrine of Copernicus, Gilbert added, "The globe of the earth is aggregated and coheres by itself electrically. The globe of the earth is directed and turned magnetically . . ." The substance of Gilbert's concept was that magnetic attraction was entirely incorporeal and imponderable, but that electrical attraction was due to a subtle but real quality. Therefore, an electric must consist of a concreted humor which is exuded as an effluvium by attrition or rubbing. He could screen electric action by thin membranes and flame but magnetic action passed through these; this confirmed his notion of the subtlety of the electric force. He observed that electrics that wetted easily (such as glass and crystal), lost their electric quality quickly in a damp atmosphere, but that amber, jet, and sulfur, that did not wet readily, retained the quality longer.

So conscious was Gilbert of the universal importance of his work and his discoveries that he followed a unique system of designating his most important observations by placing an asterisk in the margin of the text in which the observation was treated; a major discovery was shown by a large asterisk, a minor one by a small asterisk. In the chapter on electricity, Gilbert marked 2 major and 31 minor discoveries. In all, more than a score of electrical phenomena were here first observed and recorded. Of these, the most important half dozen included: the general classification of electrics and nonelectrics; the observation that moisture and dampness hindered electrification; the generalization that electrified bodies attracted every kind of substance including metals, liquids, and even smoke; the invention of a pivoted metallic electroscope; the observation that the electric, not the intervening air, held the attractive power; the observation that heating and roasting electrics tended to dispel the attractive power.

In contrasting magnetic and electric attraction, Gilbert noted that the former penetrated flame, but the latter did not. He also noted that electric action could be screened by interposing a film of paper, fabric, or metal but that magnetic attraction would penetrate thick slabs of almost any material except iron. Gilbert was the first to recognize the function of an insulator when he noticed that water or moisture placed on the rubbed electric destroyed its virtue but that oil did not hinder it. He also observed that whereas nearly all bodies may be made responsive to electric attraction, only those containing iron would respond magnetically. Simple as these discoveries were, they still were the first significant advances in electrical knowledge in 2,000 years.

ROBERT BOYLE

THE NEXT MAJOR CHAPTER in the evolution of electrical inquiry was written by another Englishman. Robert Boyle (1627-1691), son of the Earl of Cork. His stature in science exceeds that of Gilbert because he contributed much that was new and important in so many fields, including chemistry, physiology, medicine, pneumatics, hydraulics and, of course, electricity. He helped found the

Royal Society and regarded the acquisition of knowledge as an end in itself. In 1675 he published a tract entitled "Experiments and Notes about the Mechanical Origine or Production of Electricity" (published in facsimile by Burndy Library, 1945). This constituted the first published work in English on electricity. Among the new observations which he noted were included the discovery that amber retained its attractive ability (he termed it "virtue") for some time after it had been rubbed; that in a diamond its roughness seemed to increase rather than diminish the attractive power of the stone, contrary to what had been previously held; and that a diamond was the best of the electrics to be tried inasmuch as it affected a responsive pivoted needle three minutes after rubbing the diamond had ceased. Additional observations added new electrics to former lists including white sapphire, white amethyst, carnelian, and antimony. Boyle also disproved Gilbert's deduction by showing that if the attractive body were fixed and the attracting body were movable, motion between the bodies still did occur.

To Boyle, electrical attraction, as contained in his tract, was "a Material Effluvium, issuing from, and returning to, the Electrical Body." To Nicolo Cabeo, Boyle ascribed the hypothesis that electrical behavior is like a steam issuing from the amber when heated by rubbing which, on shrinking back to the amber, brought with it light bodies that chanced to be in the way. It was Cabeo who, in 1629, published his observations on electric repulsion. A second hypothesis, held by Sir Thomas Browne and Sir Kenelm Digby, taught that when amber was chafed or heated it was made to emit "certain Rayes or Files of unctuous Steams, which when they come to be a little cool'd by the external air, are somewhat condens'd and having lost their former agitation, shrink back to the body whence they sallied out and carry with them those light bodies, that their further ends happen to adhere to, at the time of their Retraction: As when a drop of Oyl or Syrup hangs from the end of a small stick, if that be dextrously and cautiously struck, the viscous substance will, by that impulse, be stretched out, and presently retreating will bring along with it the dust or other light bodies that chanced to stick to the remoter parts of it."

A third hypothesis, ascribed to Descartes, accounted for electrical attraction to the "intervention of certain particles, shap'd almost like small pieces of Ribbond, which he supposes to be form'd of this subtile matter harbour'd in the pores or crevices of Glass."

Boyle found that not only was glass capable of emitting electrical effluvia, but also that if two pieces of glass were to be dextrously rubbed together for two or three minutes "you will find that Glass is not onely capable of emitting Effluvia, but such ones as to be odorous, and sometimes to be rankly stinking." Boyle summed up his own position by concluding that electric attraction was no mere quality but substantial emanations from the attracting body. In all, a mechanistic interpretation of the phenomenon was maintained, one in which "tersion," the process of wiping and chafing, was required to cause amber to draw such light bodies as straw, hair, and the like. He pointed out that whereas magnetic steams were

Robert Boyle.

so subtle that they penetrated all kinds of surrounding media, yet "Electrical Steams are like those of some odoriferous Bodies, easily check'd in their progress . . ." If the air was thick or cloudy and especially if the south wind blew, the electrical attraction was weakened. The north wind improved and the day was better than the night for electrical display. Smoke responded to rubbed amber as did fine sand and mineral powders, steel and copper filings, and beaten flakes of gold. Uncut amber and diamond were more strongly attractive then cut ones. The attrahent might be amber, hard wax, sulfur, diamond, or "like unctuous Concretes." If the receiver of an air-pump was evacuated, straws and feathers were attracted by amber that was rubbed before the air was exhausted. This constituted Boyle's most important contribution to electric knowledge. He had convinced himself that crystal, carnelian, white sapphire, emerald, and English amethyst were true electrics although his predecessors Gilbert and Kircher were uncertain of this.

(The June issue will carry a description of the first electric generator and an account of the pioneering investigations into the relationship between light and electricity as well as the ingenious machines and experiments devised to probe this relationship.)

Electricity in the International Geophysical Year

H. E. NEWELL, JR. CHARLES DE VORE

The electrical highlights of the International Geophysical Year to begin on July 1, 1957, are reviewed. Included under this topic are electrical studies of the ionosphere, current rings far beyond the atmosphere, cosmic rays, the aurora, whistlers, sunspots, and electromagnetic phenomena. Information to be gathered will be so massive that a generation or more will be necessary to reduce and interpret it all.

THE INTERNATIONAL GEOPHYSICAL YEAR (IGY) will soon begin. This greatest scientific undertaking in the history of the world will run from July 1, 1957 to December 31, 1958, covering actually a year and a half instead of just a single year. During this period, more than 50 nations will make a combined attack upon the scientific problems of the earth, the earth's atmosphere, and the sun. They will set up and man hundreds of observing stations forming a net that will completely cover the globe, and at these stations they will amass the most complete set of data on geophysical and solar phenomena that has ever been collected.

Many of the phenomena to be studied are world wide in nature, and simultaneous correlated observations over the entire globe are required to give the complete picture needed for understanding them. The isolated and uncoordinated observations of the past have not been sufficient to solve some of the most fundamental problems, but the sweeping IGY attack is expected to lead to major breakthroughs on many fronts. In addition, the techniques devised for the IGY studies, new instruments, and the new knowledge obtained will have great practical import.

Although this will be the first International Geophysical Year, it should be remembered that there have been two previous occasions during which scientists of the world united in their common search for knowledge. These were the First and Second Polar Years, which took place in 1882 and 1932, respectively.

Scientists of more than 30 nations joined in the Second Polar Year. One important result of practical value from this undertaking was the recognition that there was a correlation between radio blackouts and periods of great geomagnetic and earth-current disturbances. This problem still confronts us today.

It will also be of special interest to electrical engineers to reflect that a new meteorological instrument, the radiosonde, was introduced during the Second Polar Year. Today, the rocket sonde is an established scientific device. Perhaps the earth satellite will prove of comparable value as a scientific instrument, as a direct result of its introduction during the IGY.

If the 50-year interval had become standard, the next world scientific program would have been due in 1982. The great advances in the past 25 years, in scientific discoveries as well as in scientific instrumentation, however, dictated an IGY 25 years sooner. Many of the new instruments resulted directly from military research and development, during and following World War II. In fact, the earth satellite program is feasible because of the knowledge and experience gained from upper atmosphere research with balloons, rockets, and rocket-balloon combinations that have been performed since 1946, either by civilian scientists within the Department of Defense, or by civilian scientists working under the sponsorship of Department of Defense contracts.

A word now about the organization for the IGY. A special group, known as the Comité Speciale Année Géophysique Internationale (CSAGI) was formed by the International Council of Scientific Unions in 1951. In turn, each of the more than 50 nations participating in the IGY has organized national committees to co-ordinate their national scientific programs. Here in the United States that group is the U.S. National Committee for the IGY, established by the National Academy of Sciences–National Research Council. The various phases of the over-all United States scientific program are the concern of 13 separate technical panels.

The earth and its atmosphere comprise our dwelling place, while the sun is our single greatest source of energy. The more that can be learned about these, the greater the dominion over them that can be achieved. It it expected that out of the IGY effort we shall eventually have better weather forecasting, which is of tremendous commercial, agricultural, and industrial importance. Many look to the ocean as a principal means of solving the very serious problem of providing enough food for the rapidly growing population of the world. Thus, knowledge to be gained about the ocean may prove to be of incalculable practical value. Increased familiarity with the earth's crust and its resources should eventually have a beneficial impact on mining and the commercial development of those resources.

Not the least in practical value will be the knowledge that the IGY will provide about the electrical aspects of our earth and its environs. An obvious area of practical importance is that of communications, both by cable and by radio, and it is to be expected that an eventual conse-

H. E. Newell Jr. and Charles De Vore are with the U. S. Naval Research Laboratory, Washington, 25, D. C.

quence of the IGY effort will be improved communications. In addition, one can be assured that other benefits will derive from the IGY program, even though the specific form of those practical outcomes cannot now be predicted.

It is the purpose of this article to review some of the electrical studies to be made during the IGY. Included under this topic are such things as: the ionosphere, current rings far beyond the atmosphere, cosmic rays, the aurora, whistlers, sunspots, and electromagnetic phenomena. The article is intended to be illustrative only, and no attempt will be made to cover the IGY program completely.

THE IONOSPHERE

THE IONOSPHERE received major attention during the Second Polar Year. This was not surprising, because it had been only seven years earlier, in 1925, that Breit and Tuve had performed their classic experiment and discovered the radio-reflecting properties of the ionosphere. Knowledge of the characteristics of the ionosphere in the polar regions was gained for the first time in the 1932-1933 period.

As is now well known, this ionosphere consists of the upper portions of the earth's atmosphere that are partly ionized. The E-region of the ionosphere lies in the neighborhood of 100 kilometers altitude (approximately 62 miles), while the F-region is two or three times higher. Most of the ionization is caused by ultraviolet and X-ray radiations from the sun, although some of it may be due to the impact of meteoritic particles. At times of enhanced solar activity, a D-region of the ionosphere appears between 60 and 70 kilometers (approximately 40 miles).

There is much still to be learned about the ionosphere. It is already known that the ionosphere is a very complex sort of thing, its behavior and state interwoven with the state and behavior of other aspects of the atmosphere and the sun. The primary item of interest in connection with the ionosphere is, of course, the distribution with height of charge density. But even this parameter gives only a partial picture. No thorough understanding of the ionosphere can be had without knowing the exact nature of the ions at the various levels, or of the solar radiations that give rise to the ionization in the first place. Nor can the study of this region be approached as though it were a static phenomenon. Just the opposite is true. With the rising and setting of the sun, with varying activity on the sun, with the changing seasons, and with varying motions in the upper atmosphere the ionosphere also varies, and it becomes an intricate puzzle indeed to unravel the separate effects. Moreover, since the ionosphere is an electrical phenomenon, it may be expected that its behavior will show some dependence on its position in the earth's magnetic field. The ionosphere also shows great complication in the auroral zones where it is believed that the atmosphere is being bombarded with charged particles from the sun.

During the IGY, it is planned to study the ionosphere on a world-wide basis, so as to get a complete picture of the ionosphere over the entire world as a function of time of day and of year. With the extensive data to be obtained during the IGY, it will be possible to correlate ionospheric conditions with solar, magnetic, and auroral activity.

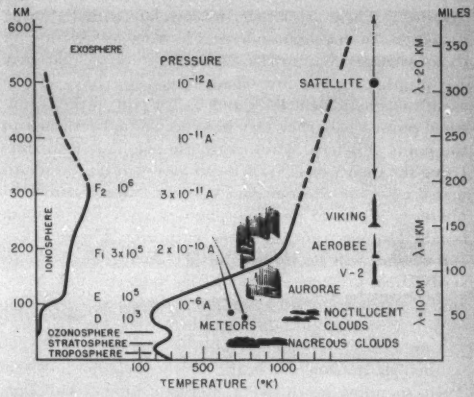


Fig. 1. Solid lines illustrate data obtained within the last 10 years by means of instrumented rockets, balloons, and rocket-balloon combinations.

The usual pulse-height radio soundings of the ionosphere will be made on a greatly expanded basis. Both the forward and back scattering of radio signals will be observed. With a properly chosen network of stations, it will be possible to make synoptic studies of sporadic E signals reflected from the aurora, meteor ionization trails, and the regular ionospheric layers. The high ionospheric absorption that occurs at high latitudes will also be studied. Also, measurements will be made of the sum total of terrestrial radio noise at a number of fixed frequencies.

A most important supplement to the many ground-based observations of the ionosphere will be the rocket studies to be made. Especially in the auroral regions, the charge density of the upper atmosphere will be determined by the use of rocket-borne transmitters. These on-the-spot measurements will be invaluable in calibrating the indirect ground observations. At the same time, rocket-borne mass spectrometers will be used to determine directly the ionic and chemical composition of the upper atmosphere, especially in the ionospheric regions. With photon counters, the rocket will also determine at what altitude levels and in what amounts the various solar wave lengths are absorbed. These data, together with rocket observations of pressures, temperatures, and densities will be fundamental to the development of an adequate theory and to the interpretation of the ground based results.

WHISTLERS

IT HAS BEEN KNOWN for some time now that a radio receiver sensitive directly to the audio range can pick up sporadic signals aptly described as "whistlers" and

"swishes." These are known to correlate with lightning discharges in the atmosphere. The time correlation of these whistlers and swishes seems to indicate that they are propagated out into space along the lines of the earth's magnetic field lines and back again to the conjugated point where they may be reflected and returned to the point of origin, again along the magnetic field line. Using the theory of Eckersley and Storey, it has been estimated from the whistler data that the density of ionized matter well beyond the atmosphere is equivalent to some hundreds of electrons per cubic centimeter. The whistlers and swishes will be studied further during the IGY, to verify their propagation along the magnetic flux lines, and to get more information about the ionic population of the regions beyond our atmosphere.

Another audio-frequency radio phenomenon is found in the "dawn chorus," heard in the neighborhood of dawn, sounding much like a chorus of pipers. Although these are known to correlate with geomagnetic disturbances and the aurora, there is as yet no suitable theory of the dawn chorus. IGY data on this phenomenon will be compared with geomagnetic and auroral observations in an effort to understand it better.

AURORA AND AIRGLOW

BOTH THE AURORA AND AIRGLOW are observed as radiations emanating from the upper atmosphere. From this aspect they are similar, both consisting largely of lines and bands of oxygen and nitrogen, although the airglow is very much fainter than the aurora, and in fact is not noticeable to the naked eye. The total intensity of the airglow amounts to several times that of starlight, diffused over the night sky, whereas the auroral intensities are thousands of times greater.

Although the airglow and the aurora have certain spectral similarities, it is believed that their origins are basically different. The airglow is believed to come from photochemical activity induced by the absorption in the air of sunlight in the ultraviolet and X-ray wavelengths. The aurora, on the other hand, is thought to be caused by charged particles from the sun impinging upon the upper atmosphere and generating the electrical discharge that we see as the visible aurora. In support of this belief, fast moving protons have actually been noted in some auroral spectra, first by Meinel and subsequently by other observers.

Although the aurora has been studied intensively for over half a century, there is still no satisfactory theory of the phenomenon. No one has yet been able to formulate a theory which simultaneously explains how particles are ejected from the sun with the correct velocities, pass between the sun and the earth, enter the earth's atmosphere through the earth's magnetic field, and then give rise to the auroral display. One of the primary aims of the IGY program will be to obtain the data needed to generate a suitable theory of the aurora.

One set of the IGY auroral observations will be directed at determining the geographical incidence of the auroras. For this purpose, the auroras will be observed visually around the world, largely by amateurs under professional guidance and direction. They will also be photographed using special all-sky cameras. A number of radar stations will also be used to observe the auroras by radar.

A second set of auroral studies will be the spectroscopic observation of the auroras. It is planned to obtain profiles of the spectral features along meridional lines, including studies of the variations of spectral components as functions of the type of the aurora, the height, and the latitude. With scanning spectrometers, it is planned to study the rapid changes in the auroral spectrum during periods of great geomagnetic activity.

By monitoring the radio noise from radio stars, it may be possible to detect the passage of an auroral beam or a cloud of auroral sporadic E across the line of sight. This would be noted by marked changes in the scintillations of the radio stars. Auroral absorption can also be measured by determining its effect on the extraterrestrial radio noise at suitable wavelengths, and this will be done during the IGY. Finally, there will be an effort to study the generation of radio noise associated with auroras. Whether this noise actually is generated by the aurora, or originates elsewhere and is simply reflected or scattered by the aurora is one question to be answered.

In the case of the airglow, it is planned during the IGY to determine the geographical and height distributions of the OH bands in the infrared region, the red and green oxygen atomic lines, and the D-lines of sodium, and their intensity variations as functions of time. Modified Roach-type photoelectric photometers will be used to make the observations.

Direct observations of the incoming auroral particles will be made with rocket borne detectors. Rockets will also be used to measure auroral luminescence in both visible and ultraviolet wavelengths, and to locate the heights of their origin. Similar studies will be made of the airglow. The rocket firings will take place in the northern auroral zones from shipboard and at Fort Churchill in Canada, at White Sands, N. M., and also from shipboard in the Antarctic. Aerobees, two-stage Nike-Cajuns, and balloon launched Rockoons will be used.

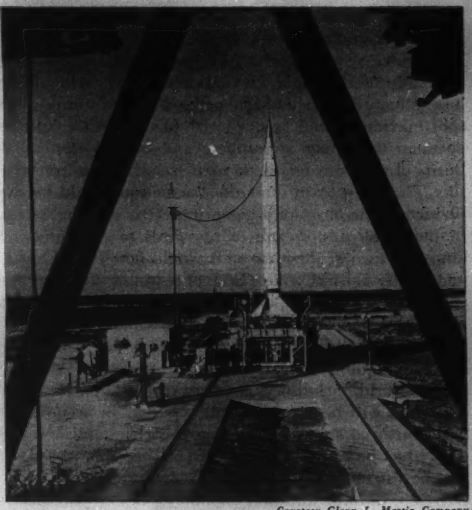
SOLAR RADIATION

THE SUN WILL BE ONE of the most important objects of study during the IGY. Solar terrestrial relationships are exceedingly complicated, but at the same time fundamental to the understanding of the physics of the earth and its atmosphere. The IGY period comes at the time of maximum sunspot activity, and the IGY solar program will be particularly concerned with sunspots, flares, plages, emissions from the corona, solar magnetic fields, and radio-wave emissions. Detailed solar observations, normally confined to a few hours per day, will be expanded to cover a much greater part of the available observing time. There will be a close co-operation between observatories in different longitudes so as to ensure a 24-hour per day watch on the sun. There also are plans to make special observations of the sun in both the visible and radio regions during the October 1958 eclipse.

Among the most fundamental observations will be

those carried out in rockets. The entire spectrum from the near ultraviolet down through the hard X-rays will be measured in a number of rocket flights during the IGY. Not only will the solar intensities be measured as a function of height above the ground, but also an effort will be made to obtain the intensities well above the atmosphere before absorption in the air. In vertical sounding rockets, photon counters will be used to obtain the total intensities in selected wavelength regions throughout the spectrum. More detailed information will be gotten from sun-following spectrographs, capable of photographing the spectrum way down into the far ultraviolet. Satellite-borne ionization chambers will study the solar ultraviolet in the Lyman alpha (1,216 A) region well beyond the appreciable atmosphere. From these satellite observations the free-space solar intensities and their correlation with solar flares and similar activity will be determined.

Radio telescopes will be turned toward the sun to record its activity in the radio wavelengths. This extension of the solar patrol will be carried on throughout the IGY, making it possible to correlate solar activity as seen in the visible wavelengths with the activity as it appears in the radio portion of the spectrum.



Courtesy Glenn L. Martin Company

Fig. 2. Viking rocket readied for take-off.

CURRENT FLOWS

THERMAL AND TIDAL MOTIONS in the upper atmosphere associated with the sun and moon give rise to currents within the ionosphere. These currents are world-wide in scope, and have a measurable effect on the surface value of the earth's magnetic field. It is expected that the greater part of these current flows is to be found in the E-region of the ionosphere and, in fact, one rocket magnetometer observation made a number of years ago indicated just this. The observation was incomplete, however, inasmuch as the rocket did not go high enough to clinch the point. It is intended, therefore, to continue these rocket observations of ionospheric current flows during the IGY, and to attempt to correlate these rocket observations with ground-based measurements of the earth's magnetic field.

In addition, it is hoped to use very high flying rockets and satellites to detect the presence of current flows far beyond the atmosphere. The current flow referred to here is the so-called Chapman-Stoermer current ring, supposed to exist at a distance of several earth radii from the surface of the earth. This current ring is believed to be generated by charged particles from the sun, which are deflected by the earth's permanent magnetic field into a ring about the earth. During a period of solar activity, the intensity of the ring is enhanced with fresh particles from the sun, giving rise to an increased magnetic field effect at the surface of the earth. Subsequently the ring intensity falls as particles are lost from it to space. It is further thought by some that some of the particles spraying off from the current ring find their way into the earth's atmosphere in the auroral regions, giving rise to the aurora. In this picture, the Stoermer current ring becomes the immediate source of auroral particles, although the sun is still regarded as the ultimate source.

With magnetic field observations from a satellite, and simultaneous observations at the surface of the earth, one will be able to obtain two sets of field intensity curves. One of these sets will contain the sum of components due to the ionospheric and Stoermer ring currents, while the other will contain the difference of these components. After taking into account the main field of the earth, it should then be possible by adding and subtracting the resulting curves, to separate the ionospheric current effect from that due to the Stoermer ring. If such an effect is obtained, this will then firmly establish the existence of the ring current. Because of the association of the Stoermer ring with pronounced magnetic activity, the foregoing observations are of special IGY interest.

It has long been noted that certain identifiable patterns in the ionosphere move as though they were being carried along by high altitude winds. It is planned during the IGY to continue observations of these ionospheric drifts, as they are called. Many, however, believe that these are not due to actual mass transport of ionospheric matter, but rather are the result of a propagation of some localized electrical state of the ionosphere. If such is the case, then this phenomenon is not properly included as a genuine current flow.

EARTH'S MAGNETIC FIELD

ALTHOUGH THE EARTH'S MAGNETIC FIELD is, in the main, quite stable, it does show certain small variations. Some of these variations are quite slow, involving years. Others are relatively rapid, occurring in days, hours, minutes, and seconds. Although these variations are rarely more than 2% of the total field, nevertheless, they involve fairly large amounts of energy, and often are associated

with pronounced effects in the sun, the aurora, the ionosphere, and radio propagation.

A principal part of the IGY geomagnetic program is the study of the rapid fluctuations in the earth's field. These fluctuations should be at a maximum during sunspot maximum, and are believed to be due to disturbances in the upper atmosphere and beyond caused by bursts of electromagnetic or particle radiations from the sun. The main features of the fluctuations could be explained in the terms of a gigantic electric current system in the upper atmosphere of hundreds of thousands of amperes. Two of these currents would flow in the north and south auroral zones, and one would flow in the equatorial region. One objective during the IGY will be to establish the existence of these currents, and to study their nature and their causes.

Magnetic observatories will be in operation throughout the world, including stations in the Antarctic regions. The data will be recorded and reported in accordance with universal standards that have been established. In the reduction and interpretation of the data, the data will be correlated with other IGY data such as solar activity, the aurora, and the ionosphere, Also, as previously stated, magnetic field data will be obtained from the IGY satellites, and these will be studied in conjunction with the ground based observations.

COSMIC RAYS

THE MOST ENERGETIC PARTICLES known to man are found in the cosmic radiation. As is now known, these rays in space consist of charged particles moving at relativistic speeds. About 80% of them are protons; 19% are alpha particles; and the remainder consists of heavier nuclei in roughly the cosmic abundances. The energies vary from about 5×10^8 to 10^{19} electron volts or more. There is a correlation between fluctuations in the cosmic ray intensity and solar and magnetic activity.

During the IGY, it is planned to study the primary cosmic-ray mass and energy spectrum, the low energy end of the spectrum, and fluctuations in total intensity. Ground, balloon, aircraft, and rocket observations will be made. Cosmic-ray telescopes, air shower detectors, ionization chambers, neutron monitors, and rocket-borne counters will be used.

In a special effort to examine the low energy part of the spectrum above the atmosphere, detectors will be flown in the IGY artificial earth satellites. Correlation of the cosmic radiation with solar activity and solar-influenced terrestrial activity will be sought.

EARTH'S ELECTRIC FIELD

THE EARTH HAS AN ELECTRIC FIELD which shows some variations but is on the order of 100 volts per meter at the surface through the atmosphere of the earth. There is a more or less steady current flow of about 10^{-12} amperes per square meter. The total potential difference between the earth's surface and somewhere in the upper atmosphere, presumably the ionosphere, is estimated at 290 kv. Because of radioactivity in the earth itself and the ionizing effect of cosmic radiation, there is a conductivity in the atmosphere amounting to about 10^{-14} mhos per meter. These various parameters in the neighborhood of the earth's surface are modified by weather, and by industrial and similar pollution of the atmosphere.

Certain small groups around the world are active in the study of these things, and although there is no extensive IGY effort planned in this field, nevertheless, the measurements made by the specialist groups in this field will add to the sum total of the IGY results. In particular, the existence of complete meteorological data for the IGY period should aid in the correlation of electric field, conductivity, and conduction current data with meteorological parameters.

SPECIAL IGY INSTRUMENTATION

IN ORDER TO UNIFORMIZE the IGY results, much of the instrumentation to be used will be standardized equipment, previously developed and proved. Included in this category will be meteorological sondes, balloons, ionospheric pulse-height sounding gear, magnetometers, photometers, telescopes, spectroheliographs, cameras, radio receivers, ionization chambers, geiger counters, etc. There will, however, be a number of specially developed instrumentations. Some of these will be discussed.

One of the most significant inventions of the past decade is the nuclear resonance magnetometer devised by Packard of Varian Associates. In this device, a container of proton rich substance such as water is enclosed in an electric coil. When the coil is energized with a strong current, the magnetic field generated causes the magnetic moments of the protons to align themselves with the field. If the current is then turned off, the proton magnetic moments will then precess, coherently now, about any residual field such as the earth's. Because of the coherence of these precessions, a measurable emf is generated in the coil which can be amplified and recorded. It turns out that the frequency of this signal is independent of the direction of the residual field but does depend on the total intensity of the field. Thus, by determining the signal frequency one can determine the total intensity of the ambient field. With care, the field can be determined to a fraction of a gamma. This type of magnetometer will be used during the IGY in a large number of rocket sounding experiments to measure the earth's magnetic field up through the ionosphere, and in the IGY satellites to determine the field above the atmosphere.

In the rocket solar radiation and auroral luminescence studies, special type photon counters developed by H. Friedman and colleagues of the Naval Research Laboratory will be used. The lower wavelength cutoff will be effected by means of special windows, in the usual fashion. A longwave cutoff will be achieved, however, by varying the filling of the counter. Using different amounts of electronegative gases in the filling, the position of the uppper wavelength cutoff can be positioned quite accurately. By this scheme, counters with acceptance bands of a hundred angstroms or so can be constructed.

The usual type of magnetic field mass spectrometer is much too heavy and cumbersome to operate in a rocket sounding vehicle. For this reason, J. W. Townsend, Jr., of the Naval Research Laboratory undertook to modify the Bennett type radio-frequency mass spectrometer for rocket use. He was successful, and a number of rocket flights have now been made with it, giving data on both the ion and chemical composition of the upper atmosphere. In this device, ions are directed along a glass tube through three separation stages of grids. The voltages on these grids are varied at suitable radio frequencies to make ions of a given mass-to-charge ratio pass through all three stages, but to forbid the passage of all other ions. The mass-to-charge ratios admitted can be varied during operation in order to sweep over a large range of mass numbers in an interval of about one second. Thus, for rocket use, the range can be selected to cover that of interest in studying the ionosphere. Such spectrometers will be flown in a number of rockets during the IGY, to study the ionosphere above Ft. Churchill, Canada.

In order to examine the sun's spectrum in detail in the far ultraviolet region, it is necessary to make long exposures of film above the atmosphere. To permit this to be done without smearing the spectrogram, it is necessary to point a spectrograph steadily at the sun. This is to be done in rockets flown during the IGY by means of a sun-following device. This device uses an array of photocells to detect the position of the spectrograph axis relative to the direction to the sun, and generates a signal to move the spectrograph so that its axis points toward the sun. One sun follower of this type developed by the University of Colorado has been very successfully used during the past several years, and will be used during the IGY.

In order to make the most of the IGY observations, great care will be taken to see that as many observations as possible are made simultaneously. There will be a series of World Days, on which all significant observations are supposed to be carried out by all observers. In addition, there will be an effort to call all observers into action when it appears likely that there will be unusual activity in the sun, or when something unusual is already in progress. To effect this program, it will be necessary to establish and maintain an extensive system of communications. Radio, telephone, and teletype will all be used. Existing nets, like that of the World Meteorological Organization will be used whenever possible. The National Bureau of Standards radio forecasting center located at Ft. Belvoir, Va., will be the World Warning Agency, and will act with advice of similar centers in other countries.

CONCLUSION

THE PRESENT ARTICLE has given only the highlights of the electrical aspects of the International Geophysical Year. It is hoped that enough has been given, however, that the reader will have gotten some appreciation of the tremendous scope of this scientific effort. Out of the activity of the IGY there will come such a mass of information and data, that it will take a generation or more to reduce and interpret it all. Both geophysics and solar physics should receive a tremendous impetus from the IGY results. Many important and fundamental problems will be solved in the course of the program. And many practical benefits in the way of improved knowledge about weather, radio communications, mineral prospecting, development of food resources, etc., are bound to ensue.

The reader who would like to go into the IGY program in detail is referred to the various national reports put out by the National Committees for IGY, and disseminated by the Special Committee for IGY, the headquarters of which are in Brussels, Belgium. Within this country, detailed information can be obtained by writing to the National Committee Headquarters, at the following address:

U. S. National Committee for IGY, National Academy of Sciences-National Research Council, 2101 Constitution Avenue, N. W., Washington, D. C.

New Mineral Detector

R. Parker, Toronto engineer, operates the Ronka Ground EM unit, used in conjunction with another similarly equipped prospector to detect scarce lead, zinc, and copper deposits. Although recently introduced, the electromagnetic device has proved its value in over a year's operational and experimental service by various companies. Airborne FM units developed by Aeromagnetic Surveys Limited engineers, Toronto, Ont., Canada, who developed this ground unit, recently located six rich mineral bodies worth many millions of dollars.

A Quarter Century of Experience in Insulation Co-ordination

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Basic philosophy and principles underlying the rationalization of system insulation strength are presented. The development of a program of insulation co-ordination, its application and operating experience with the American Gas & Electric Company system is described.

THE SUBJECT of insulation co-ordination, as the term is now generally used, was first brought to the attention of the American Institute of Electrical Engineers (AIEE) on a broad, comprehensive basis in a paper by one of the authors in 1928 entitled "Rationalization of Transmission-System Insulation Strength." Since that time, wide interest has developed in the subject, and much time, thought, energy, and expenditure of money have gone into an attempt to solve the many problems associated with the subject.

The American Gas and Electric (AGE) System includes practically all transmission voltages and associated equipment ranging from 2.3-kv to 345-kv rating inclusive, but excluding 230 and 287 kv. It includes over 72,000 pole miles of line and over 1,200 substations or stations. Therefore, the authors' interest is not confined to any one or two system voltages, or a few stations, but to practically the entire range of standard voltage ratings in use today and many stations. Further, from the start, the writers have been concerned with the co-ordination of insulation on the systems as a whole, not merely with the protection of one piece of equipment such as a transformer or circuit breaker.

PROGRESS IN INSULATION CO-ORDINATION

THE BASIC PHILOSOPHY of the aforementioned 1928 paper on rationalization of system insulation was that the insulation levels or breakdown characteristics of insulation of the several elements in a transmission system be so arranged for any system voltage, or for any level of insulation chosen, that in case of an insulation failure, it would be confined to the place on the system where it would result in the least damage, would be the least expensive to repair, and would cause the least hazard to continuity of service.

Progress in insulation co-ordination was at first slow due to the lack of fundamental data. Practically all of the information which is available today and used intelligently in applying lightning protection was nonexistent in 1928.

Rapid progress was made in developing the tools and equipment and in organizing field and laboratory research to obtain the much needed information. The nature of lightning on the transmission line itself, as well as its characteristics on reaching stations were uncovered by continued field research. The insulation strength of equipment was also determined, not only for air insulated elements, such as insulators and external bushing insulation, but also for the more complicated and expensive equipment such as transformers, some types of bushings, and similar equipment. A standard voltage test wave was adopted and commercial testing of transformers was developed to determine their safe impulse strength, and is now everyday practice in the industry. The protective characteristics of lightning arresters were studied extensively in the laboratory and, from the results of field tests, the lightning current surges that the lightning arresters were required to pass in service were measured and established.

The Triple Joint Insulation Co-ordination Committee of AIEE, Edison Electric Institute (EEI), and National Electrical Manufacturers Association (NEMA), representing the technical aspects of the problem, the practical and economic aspects of power system operation and performance, and the equipment manufacturer's point of view, have heartily co-operated in bringing out the proposed standard basic impulse insulation level (BIL) of 1941. It is interesting to note that these have stood the tests of time unusually well; although a review of their composition has been in progress during the past ten years or so, few proposed changes have been offered to date.

PRINCIPLES AND BASIC PHILOSOPHY

THE RATIONALIZATION of system insulation strength and the implementation of insulation co-ordination involves a number of basic principles, and has led to the acceptance of a number of necessary rules of practice:

1. The lightning arrester is taken as the basic protective device; this establishes a level of overvoltage above which equipment will be protected. Inasmuch as the arrester is a voltage sensitive device, it must be carefully correlated with the system voltage.
2. System voltages carry three designations: first, nom-

Revised text of paper 57-172, "A Quarter Century of Experience in Insulation Coordination: Basic Philosophy, Application, and Operating Experience on the American Gas and Electric Company System," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N.Y., Jan. 21-25, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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inal voltage, which is the approximate line voltage distinguishing one system from another; second, rated voltage, which is a base figure for which equipment is designed and which is suitable for continuous operation of equipment; and third, maximum system voltage, which is the voltage that insulation must withstand in service and at which arresters are applied. Obviously the last is also a value which must be taken into consideration by the equipment designers.

3. Two different types of systems are recognized: the isolated neutral system, and the effectively grounded system. The latter will be referred to in this paper merely as "a grounded system."

On all systems in the transmission class it is expected that the maximum voltage may, under operating conditions, sometimes attain a voltage 5% higher than rated voltage. This conforms to general practice being followed today on all types of major equipment.

4. The rating assigned to lightning arresters is understood to be the maximum 60-cycle voltage under which they will operate successfully in service. On isolated neutral systems, the arrester should have the maximum rating not less than the maximum rating of the system. Such an arrester is called a "full rated" or 100% arrester. On grounded systems, the arrester maximum rating can generally be 80% or less of the maximum system voltage. Special studies and applications have resulted in the past in using arresters as low as 75 or 70% of maximum system rating.

5. In the selection of transformer insulation the term "reduced insulation" has often been used in the past. The question arises "reduced from what?" If the BIL's originally set up in the 1941 report are taken as the levels of equipment required for system voltages given in column 1 of Table I, then any reduction in the BIL's become reduced values.

To show the general principle of the possibility of using reduced insulation on transformers, column 3, obtained by taking 80% of the BIL of column 2, has been added. Thus, if a grounded neutral 138-kv system can use an 80% arrester, it can also use an 80% BIL of 520 kv. It is fortunate that the BIL's and reference class system voltages recommended by the AIEE, EEI, NEMA, Insulation Co-ordinating Committee and included in Table I, are in the general order throughout the entire range of 23 kv and above, tied together by the relationship that any BIL is in the rough order of 80% of the next higher BIL. A careful analysis of Table I shows the intriguing possibilities of using reduced insulation on transformers and other equipment with obvious economic advantages.

Two other important elements have been given weight in the development of proper principles of rationalization of insulation strength and the implementation of insulation co-ordination: one is the volt-time characteristic of the insulation which is to be protected, such as the transformer, oil circuit breaker, insulator, etc., and the other is the volt-time protective characteristic of the arrester. A corollary is that in applying an arrester to protect a transformer or similar equipment, a sufficient margin must be allowed between the arrester protective level and the insulation strength of the equipment, regardless of the relative location of the two in the station (distance factor).

Table I. Standard Basic Impulse Insulation Levels Adapted from AIEE-EEI-NEMA 1941 Report

Reference Class, Kilovolts Col. 1	Basic Impulse Level (BIL), Kilovolts Col. 2	80% of BIL Col. 3
1.2	30	24
2.5	45	36
5.0	60	48
8.7	75	60
12.0	95	76
15.0	110	88
23.0	150	120
34.5	200	160
46.0	250	200
69.0	350	280
92.0	450	360
115.0	550	440
138.0	650	520
161.0	750	600
180.0	825	660
196.0	900	720
230.0	1,050	840
260.0	1,175	940
287.0	1,300	1,040
345.0	1,550	1,240

LIGHTNING ARRESTER CHARACTERISTICS

Because the lightning arrester is used to establish the basic impulse protective level, it is important to recognize its characteristics so that it will not be misapplied.

An arrester has three basic characteristics which are important in use. These are: (1) rated 60-cycle voltage, not to be exceeded; (2) voltage limiting characteristics when passing lightning currents of different characteristics, and (3) thermal limit.

Table II. Lightning Arrester Protective Characteristics Station Valve Type—Maximum IR at 5,000 Amperes and Gap Breakdown Values—Kv

LA Maximum Rating Col. 1	IR Col. 2	IR Col. 3	IR Col. 4	GAP Col. 5	GAP Col. 6	GAP Col. 7
Year*	1940	1953	1955**	1940	1953	1955*
3	11	11	9	16	15	14
6	23	22	18	28	27	24
9	34	33	26	42	40	35
12	46	44	36	52	50	50
15	57	55	44	64	61	60
20	77	74	58	86	83	80
25	95	92	71	107	102	100
30	115	110	88	127	122	120
37	143	137	105	157	151	145
40	154	148	115	163	157	150
50	192	184	141	213	205	180
60	230	220	176	257	246	220
73	282	270	210	313	300	260
97	371	356	280	414	397	355
109	417	400	315	465	446	410
121	463	444	351	516	495	445
145	560	536	420	618	592	525
169	651	624	495	722	693	620
195	744	713	568	829	796	700
242	927	888	700	1,032	988	880
264	1,010†	957†	765†	1,130†	1,080†	960†

* Refers to committee reports in AIEE *Transactions* unless otherwise noted.
**NEMA LA Standards 1952, revised September 1955.
†Prorated, not published values.

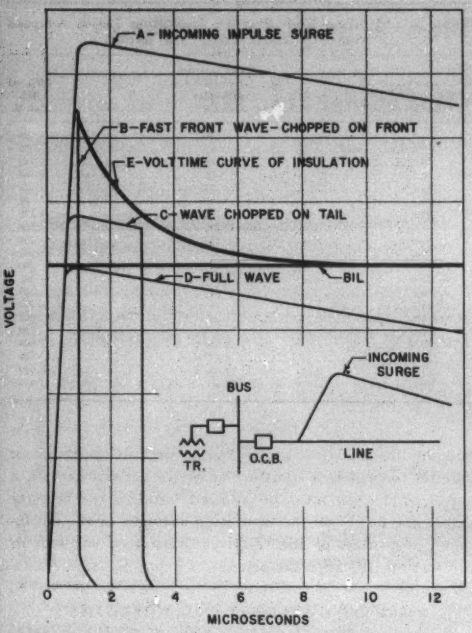

Fig. 1. Basic lightning voltages to which system insulation may be subjected when not protected by arresters.

The impulse voltage limiting characteristic of the arrester is the value it will hold at its terminals when discharging specified currents, and these voltage values vary with magnitude of current. The voltage limiting characteristic should also be recognized at short times such as at gap breakdown when the arrester first starts to function on the appearance of a surge voltage on the system, and before current starts to flow through the arrester.

The third feature of the arrester which has not been given very much consideration up to recent times, is its thermal ability, that is, its ability to pass repeated or long time surge currents (such as switching surges) without an internal temperature rise which will disrupt the arrester, even though it has been applied within its 60-cycle rating.

The protective characteristics of station type arresters of various ratings from 3 kv to 264 kv are given in Table II.

The improvements made in station type arresters (Table II) have not been reflected to any degree in the distribution class of arresters, but on the other hand have been reflected to almost the same degree in the line type arrester.

INSULATION CHARACTERISTICS

A CONCEPT OF THE TYPES of lightning voltages which the arrester will have to protect against is now presented. The early thinking of the authors led them to the conception that a lightning voltage appearing on a transmission line could come into a station as indicated in the inset of Fig. 1. Depending on the magnitude of such a surge initiated on the line, it might come into the station as a wave of steep front chopped on the front, or a wave of steep front chopped in 3 microseconds or so on the tail, or it might appear at the station as a full wave.

About 1934, the first 138-kv transformer on the AGE system was given a factory impulse test, and since that time it has been an established practice to test one or more power transformers in a bank, and more recently all transformers in the voltage range of 138 kv and above, and in some cases even at lower voltages.

Time and again failures have occurred on transformers while being impulse tested in the factory, and the faults and conditions thus located have been corrected. However, in more than 20 years of impulse testing, no power transformer *successfully impulse tested in the factory* has ever failed from lightning after being placed in service in the field.

There are, of course, three types of voltages which insulation has to withstand in service: the normal frequency continuous voltage of the system; the impulse or lightning voltage which may be imposed on the equipment even though protected by arresters, and the switching surges about whose characteristics not enough is known, and not too much, consequently, as to their effect on insulation. This is a field that surely needs further exploration at the present time; therefore, it is hoped that the work which is now being done will be continued and intensified.

LIGHTNING ARRESTER APPLICATION

SUCCESSFUL APPLICATION of lightning arresters in insulation co-ordination to give an optimum result is more involved than is commonly appreciated. The following outline of procedures followed on the AGE system represents, in the authors' judgment, a rational approach:

1. The 60-cycle rating of the arrester is selected so that its rating will not be exceeded in service under normal or fault conditions.

2. The arrester provides a protective zone if a margin is set between arrester level and the equipment level. This zone should be of adequate range to protect all the station equipment of the same BIL as that for which the arrester was selected, or higher insulation used beyond the protected zone.

3. The lightning arrester should be located as close to the major equipment as possible, and the lightning arrester ground resistance should be low.

4. The lightning arrester thermal capacity should be checked in all cases where there are long lines with high stored energy at the time the arrester discharges.

5. The arrester maximum IR drop is taken as the arrester protective level, not the average IR.

6. A value of lightning current discharge needs be es-

tablished to obtain the arrester protective level which is to be co-ordinated with the BIL. For station application on the AGE system a current of 5,000 amperes has been adopted.

7. The effect of multiple lines in reducing the severity of lightning at a station has long since been recognized from theoretical studies; it has been proved by tests and experience over the years.

To determine the BIL, it is necessary first to determine the arrester protective characteristic (maximum IR drop at 5,000 amperes). To this is added a margin above the arrester level, the value of 30% being desirable, but 20% being acceptable. The margin is to provide added protection or insurance against many of the factors previously mentioned and against possible insulation deterioration of the equipment in service. From this value, it is a simple step to select the BIL from a table of standard values such as Table I.

An example taken from the AGE 132-kv system will illustrate this. On that system, 145 kv represents maximum voltage. The calculated line-to-ground voltage under fault conditions (the system neutral being grounded), ranges from 85 to 100 kv. Adding the margin of 10% gives a value of 110, and the nearest standard station arrester has a rating of 109 kv. If the arrester is to be expressed as a "percentage" arrester, the percentage is $^{109}/_{145}$ or 75%. Taking the IR drop for this arrester at 5,000 amperes from Table II (1940 type), and adding 30% margin, we have 417 x 1.3, or 540 kv. The nearest BIL to this is the 115-kv class of 550. This is a typical example of how 550-kv BIL was selected for the AGE 132-kv system many years ago.

INSULATION CO-ORDINATION ON THE AGE SYSTEM

In applying insulation co-ordination on the AGE system, the authors have always considered the transmission line as having insulation which is independent of the station insulation. In the early days (between 1916 and 1926) an arrester was placed at the line entrance, and line insulation for at least a number of spans from the station was slightly reduced, on the theory that if the lightning voltage could be reduced at the station entrance, it could be adequately limited by the arrester so that it would not be destructive to equipment within the station. Present practice is to bring not only the normal one ground wire into the station from the last line structure, but in some cases two or three, particularly in the higher voltage systems. Thus, in effect, dependence is placed on the lightning arrester within the station to take whatever may come in from the line, and after being reduced, if excessive, by line insulation flashover, to further reduce it on arrival at the station by the functioning of the arrester.

STATION SHIELDING

To protect the stations themselves, present practice on the AGE system, adopted as far back as 1934, calls for shielding the live wires in the station by elevated ground wires or masts connected to the ground systems. The pattern used in the stations is based on the principle that an elevated wire or mast will protect 2 feet horizontal distance for every foot vertical, the horizontal distance being measured from the foot of the mast on a plane passing through the wire to be protected, and vertical elevation being measured above this plane.

INSULATION CO-ORDINATION IN STATIONS

The co-ordination of insulation in stations, for system voltages 22 to 345 kv, is shown in Fig. 2. Here, four levels of insulation in the station are set up: the bus insulation is highest; the switch and stack insulator is somewhat lower; the transformer next lower; and the lightning arrester is the lowest. The percentages of margin between these different levels are not uniform; but are attained on a reasonably consistent basis by the use of commercially available components of equipment.

It is important to remember that the lightning arrester is tied both to the system voltage and the BIL and, thus, the BIL is tied to the circuit voltage rating. This was recognized in the 1941 Triple Joint Insulation Co-ordination Committee Report in which the BIL's were assigned, "Insulation Class," which was the approximate voltage of the circuit on which those BIL's could be used for equipment, and the equipment was then protected by the available lightning arresters with a small margin between arrester and transformer levels.

The typical protective pattern for 138-kv transformers using a 115-kv insulation class (550 BIL) and 109-kv arrester of both the 1940 and 1955 station type is shown

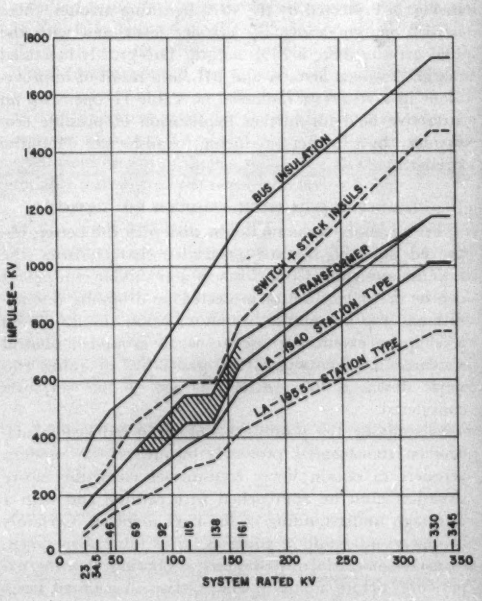

Fig. 2. Co-ordination of impulse insulation in stations.

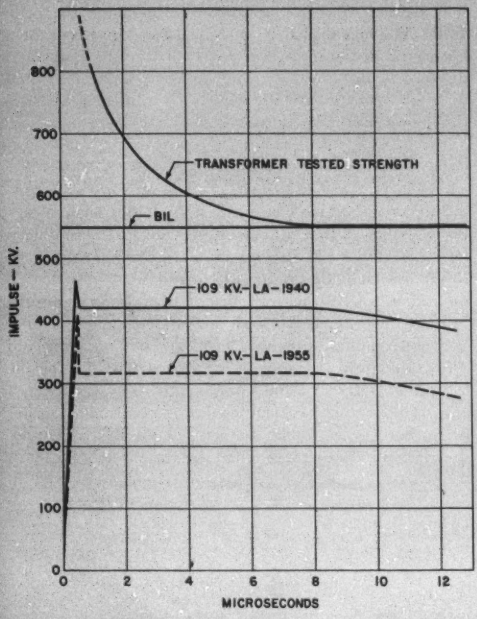

Fig. 3. LA application for protection of 138-kv transformers with 115-kv class insulation using 109-kv LA.

in Fig. 3. Protected by the 1940 lightning arrester, there is 31% margin above the arrester level, and with the 1955 arrester there is 75% margin. This greatly increased margin between arrester and BIL, as a result of improvement in arresters as indicated in Table II, opens up an attractive field for further exploration of possible economics by further reducing transformer impulse strengths.

TRANSFORMERS WITH REDUCED INSULATION

THERE SEEMS TO BE no doubt that with the better, improved lightning arrester protective characteristics, the impulse strength of transformers and similar equipment can be as well or better protected by dropping one additional step in impulse insulation below the insulation level quite extensively used now on grounded neutral systems. In other words, the possibility of going two steps down is too attractive not to be seriously considered.

In studying the possibilities of using reduced insulation on transformers protected by present day modern arresters to obtain lower transformer costs, the entire situation must be approached with caution and with a thorough understanding of the risks involved. Certainly it appears advisable in going as far as three steps down, to make some trial installations to obtain operating experience, before adopting the practice on a broad front or setting it up as an industry pattern.

One other factor, which has been mentioned before, deserves and is receiving attention: switching surge strength of insulation. If full advantage is to be taken of the better arrester protective characteristics now available, a number of other factors should be considered; one important one is the characteristics of switching surges; another important one is the performance characteristics of the arrester under abnormal or special atmospheric conditions during the time that it may be carrying out its basic function of limiting voltage with the passage of lightning current on high voltage systems.

OPERATING EXPERIENCE

VIEWING THE OVER-ALL PICTURE that has been established on the AGE system after a quarter century of study of rationalization and co-ordination of system insulation, and the application of lightning protection to systems and equipment in the implementation of these principles, the authors are satisfied that an effective job has been done, and is being done at the present time. However, they are not complacent enough to feel that the situation cannot be improved with benefits in economy and performance. They are particularly conscious of the over-all benefits which may be derived from further intensive study and application of reduced insulation made possible by use of the newer type arresters, particularly on the higher voltage systems, and their colleagues are, and expect to continue to be, active in studying this field.

Nuclear Vulcanization

Checking the first tire ever vulcanized by nuclear radiation after its first test run at the B. F. Goodrich Research Center, Brecksville, Ohio, are scientists D. Harmon, left, and C. Stockman. The scientists said tests show the tire to have considerably better resistance to aging and deterioration than conventionally vulcanized tires while the tread shows "above normal" resistance to abrasion and to wear.

Field Tests of Microwave Relaying Equipment

E. W. DOWNER
ASSOCIATE MEMBER AIEE

MICROWAVE has often been considered as a possible solution to the communication problems associated with transfer-trip and similar type relaying; however, it has been felt by many engineers that the reliability of such a system in its present state of development is not adequate. Reports of sustained outages because of propagation fading, false operations resulting from noise, and lack of a reliable primary power source have served to discourage prospective users. It is now apparent from field tests and actual operating experiences that all of these limitations can be avoided by proper selection of the microwave frequency band and equipment.

Following a two-year theoretical study of microwave for protective relaying as well as other services, an 18.5-mile system was installed between the Cleveland Electric Illuminating Company's Eastlake Generating Station and its Public Square office building in Cleveland. This 18.5-mile path, which was largely over water along the shore line of Lake Erie, was selected for test because it is considered the most susceptible to fading of all the planned microwave paths for this company. After an additional two-year testing period, a 6.9-mile system was installed between two 132-kv transmission substations for the purpose of furnishing remote tripping for two transmission lines and associated facilities. At present, the company has a total of 25 microwave protective relaying terminals in operation, all of which employ the techniques derived from the initial studies as well as the investigations conducted on the first two installations. Major test performances of the first two systems are described in the following.

Fig. 1 is a sample recording from tests on the 18.5-mile over-water system, showing the type of severe fading experienced in the 6,575–6,875-mc band used. Also included on this chart are traces for indicating false trippings as well as trip-block operations, which occur during any time that the relaying channel is receiving a substandard signal. It can be seen that channel blocking correctly occurs for only very short intervals corresponding to the very sharp fading dips which are characteristic of this frequency band. Of the two installations described, fading occurs on only the over-water link and corresponds with windless, hot, and humid periods. No significant fading has ever occurred when storms have developed in the vicinity of the microwave path.

During a seven-week test period in the summer of 1954, a total of 257,172 trip signals were transmitted at 15-second intervals on the 18.5-mile over-water system. Despite the occurrence of 728 momentary fading dips during this period, the recorded charts show that only 40 transmitted signals failed to get through, indicating a reliability associated with fading exceeding 99.98%.

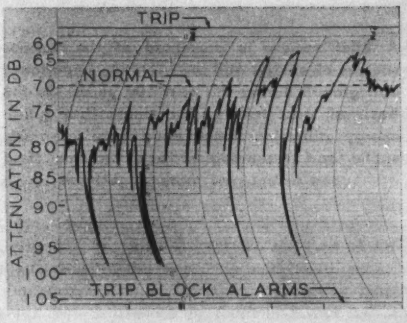

Fig. 1. Severe fading of signal between Eastlake and Public Square stations—August 17, 1955.

Further analysis discloses that never have two signals failed in sequence; thus, it is apparent that the duration of deep fades is less than 15 seconds.

The selected subchannel equipment incorporates a differential signal-to-noise comparator circuit, which constantly monitors the ratio of the received audio tone signal level to the received noise level. Thus, any substandard ratio, such as occurred during the fades shown in Fig. 1, is detected by the comparator, which electronically blocks the receiver trip relay from functioning. Total blocking speed for substandard signal conditions is approximately 2 milliseconds compared with 5 milliseconds operating speed for the electronic portion of the receiver channel. To date, there have been no false operations on any of these systems, and all channels have reliably transmitted the required relaying signals.

Although the normal primary supply voltage to the microwave is 120 volts a-c, it has been found that this particular microwave equipment will function normally down to an input of 26 volts or 22% of nominal. It is possible, therefore, to rely on the station service at locations where dips below 26 volts are not likely. At other locations, a combination motor–generator and auxiliary propane-gas engine is used. Maximum voltage dip during a switchover because of complete station service failure is 1.5 volts.

Tests and operating experience to date clearly demonstrate the adequacy of microwave for protective relaying applications.

Digest of paper 57-209, recommended by the AIEE Committees on Relays and Power System Communications and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 21-25, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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Engineers and Energy

R. E. WILSON

A brief review is presented of the various sources of energy and their relative importance and growth during the past 100 years. On the basis of past trends, it appears that future energy utilization will depend more upon scientific and technological achievements than upon actual raw material reserves.

TO ELECTRICAL ENGINEERS it is hardly necessary to say that the basic job of most engineering, not merely electrical, is to develop and use better and better methods of generating and applying energy to the work of the world. Inasmuch as we recently celebrated the centennial of organized engineering in the United States, it should be of interest to look briefly at the progress made during the past century in this area of the application of energy.

One hundred years ago, 94 per cent of the work in our country was done by the muscles of men and animals. Only 6 per cent was done by other sources of energy. Today, the situation is exactly reversed. Less than 6 per cent is now done by muscle power; the other 94 per cent is performed by the "tireless" forms of energy.

Moreover, the total amount of energy available to each person is much larger. We have not simply turned over to coal and oi lthe work formerly done by oats and hay or by meat and potatoes. We have thought up many new jobs, and we have found the energy necessary to do them.

There has been improvement in still another way. Thanks again to the engineer, we are able to do more work per unit of energy. The diesel locomotive does about five times as much work per Btu as its predecessor, the steam locomotive.

There are other, less obvious, ways in which present use of energy is more efficient. Most, though not all, of the improvement in the output of automobiles is the result of higher compression ratios, made possible by fuels of constantly improved antiknock properties.

During my own service in the industry the average octane number of gasoline has gone from about 50 to over 95—incidentally, at staggering cost to the petroleum industry. Everyone can see the tremendous changes in the automobile. However, despite the fact that about 70 per cent of our present-day motor gasoline consists of synthetic molecules not present in the crude, gasoline looks the same, smells the same, and only a high-compression engine can really tell the difference. A substantial amount of improvement is also due to better engine design. Better lubrication also has helped.

Continued study by engineers has likewise decreased the energy required in most forms of industrial processing. For example, such things as metal working require far less energy than formerly. Many of these improvements have been substantial. In some cases, the improvement factor is as much as 10.

In addition to the increase in efficiency, we must also remember the increase in convenience. Diesel locomotives are not merely more efficient than steam locomotives, they are also smoother and cleaner. And many of our modern devices give results that previously could not be achieved at all. In 1856, if you were in New York and wanted to be in London the next day there was no way you could do it, no matter how much energy and money you were willing to expend.

This factor of convenience is one reason why the number of internal-combustion power plants has grown enormously. Today the combined rated horsepower of the Otto cycle and diesel engines in the United States is over 80 times that of the central power plants using steam. Of course, most of the internal-combustion engines are operating only part of the time, but some of them, such as diesel locomotives and the diesels used in central power plants, have rather high operating factors.

Certainly, we can agree that engineers have done a good job in helping us get the most possible service out of the increased amount of energy we have had available, and in developing new devices to use energy for the benefit of man.

PAST SOURCES OF INCREASED ENERGY

IN VIEW OF THIS REVOLUTION and the great increase in use of energy, it is interesting to review the sources of these increased supplies. The story is particularly interesting if we look at the past 50 years. During that time, a major change in the pattern has occurred.

At the turn of the century, the statistical information was none too accurate, but best estimates are that the burning of coal provided about 70 per cent of the energy supply of the nation. The burning of wood provided about 20 per cent. The remaining 10 per cent of the energy market was divided between oil, gas, and water power.

By the end of World War I, oil and gas had grown to about 15 per cent of the total. Today, they supply about 65 per cent of the country's energy. Coal's percentage has faded, and wood has been almost eliminated. Even water power, with all the Government aid, has declined in per-

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centage from 5 or 10 years ago. Although we have a larger population than in 1918 and use much more energy per capita, the country's coal tonnage has actually decreased.

Although engineers have profited by, they also have contributed much to, this increased supply of oil and natural gas. A list of the things for which the petroleum industry must thank engineers would include:

1. Improvements in well drilling, from the development of rotary drilling itself to such special items as directional drilling. Out in the Gulf of Mexico, for example, as many as 10 different wells can be drilled from a single platform. However, the platform itself may cost around a million dollars, and the auxiliary equipment even more.

2. Better production methods, which increase recovery through a whole new science of reservoir engineering. Of increasing importance are the secondary recovery methods: water flooding, gas drives, use of surface-active agents, and other new techniques. Old methods frequently recovered only 20 or 30 per cent of the oil. Secondary recovery may well double the amount recovered from many fields.

3. Low-cost transportation, especially by pipeline. Engineers have developed not only very efficient pumps and drivers, but also machines to dig the ditches and assist in many stages of pipeline construction. Oil products in America go from well to refinery to terminal to consumer, an average distance of 1,000 miles, by an integrated transportation system at an over-all transportation cost averaging only 3 cents per gallon weighing 7 pounds—the cost of carrying a 1-ounce letter across town.

4. Development of electronic controls of many types, especially in refining and pipeline operation.

5. Refinery engineering, another new branch of engineering, which was made necessary by the advent of thermal cracking, a high-pressure high-temperature process. Refinery engineering met that challenge and then went on to make possible many other new processes, notably those of the catalytic revolution.

Through these and many other contributions, engineers have given us more and better energy-producing liquid fuels at amazingly low cost. That is why these fuels have been growing so much faster than other fuels.

FUTURE ENERGY

However, to an engineer I am sure the most interesting question is how our future energy needs will be supplied. Certainly, few believe that the accelerating curve of energy use will flatten off soon.

The problem of future growth, however, is by no means as easy as it has seemed to be for the past 50 years. For one thing, since the turn of the century the efficiency of central power plants, automobiles, and locomotives have all been more than doubled—some of them quadrupled. No such major gains are possible in the future.

Nor is the long-range fuel supply problem to be readily solved by the coming availability of nuclear energy. Some uninformed people seem to think that nuclear energy will soon do to oil what oil has done to coal over recent decades. If large central power plants were important consumers of petroleum products, we might be somewhat worried, but only 3 per cent of our domestic production of oil is now burned as residual fuel in such plants. Because such heavy oil is our only product which sells for less than crude oil, we have been steadily converting more and more of it into gasoline and other light fuel oils, and will shed no tears if we gradually lose the utility market, probably to coal before we do to nuclear energy.

Most of you are as familiar as I am with one of the basic facts about nuclear energy for power plants, i.e., that for several years it will not be able to compete, on an entirely unsubsidized basis, with conventional fuels in this fuel-rich nation. Indeed, the Atomic Energy Commission (AEC) is today by far the largest consumer of power in this country. However, as nuclear processes are improved and the prices of competing fuels gradually rise, an increasing proportion of the new power plants built in the United States between 1965 and 1980 probably will be designed as nuclear plants, but without displacing any reasonably efficient plant using existing fuels. On this basis, nuclear energy will be a welcome burden-sharer rather than a competitor as we face the burgeoning fuel requirements of the next half century.

There are some—either uninformed or looking for a chance to promote public power at public expense—who have criticized the AEC and the private power industry because other countries have built so-called commercial power plants before we did, and called for a major publicly financed program to build a multitude of new types of commercial nuclear power plants before they are even proved on a research scale. Actually, the AEC and the private power industry both deserve much credit for the fact that private industry is already going ahead with so many commercial plants of at least four different advanced designs, even though they do not expect that any of them will be able, for years at least, to produce power as cheaply as from coal. Other countries, lacking plentiful low-cost fuel, can afford to build proved types of reactors which they are sure will work, even though their costs will be excessive by our standards. We are well advised to take advantage of our more favorable fuel situation and concentrate on solving the more difficult problems and developing the new techniques necessary for the success of the ultimately more promising types of reactor.

Still other types of possible reactors, not yet scheduled for installation by private industry, need more research and pilot-scale work before sound conclusions can be reached as to which are most promising in the long run.

With the present serious limitations on technical manpower, money, and materials, it would be foolish to "ride off in all directions" with many more full-scale plants until we learn what we can from those now being built and from the extensive research now in progress.

Incidentally, the country should be thankful that the present administration and the AEC are following a policy of co-operation with private industry rather than

try to build up a monopoly of facilities and information in this field, as some bureaucracies would have done, and as some of the public power proponents are even now demanding. If those in Congress who really want the nuclear power program to go ahead will promptly pass the needed measure for "excess" liability insurance and not try to tack on a lot of other things, it will remove the last obstacle to a real breakthrough in nuclear power achievement.

As to other nuclear power uses, to a group of engineers I hardly need to point out that nuclear energy will probably never supplant liquid fuels for mobile equipment smaller than ocean-going vessels. Atomic locomotives are a remote possibility, but atomic automobiles seem entirely out of the question at present. Among the difficulties are, of course, the danger, the need for heavy shielding, and the high cost of any probable atomic engine as compared with the $300 engine that drives most automobiles. The same general type of limitations also will bar use of nuclear power for home heating and all other small-scale uses.

The supply of liquid fuels that we know most about is, of course, that contained in our proven reserves of petroleum. These now amount to about a 12-year supply. This may sound like an alarmingly small proven reserve, but things are not really as bad as they sound. Certainly, it does not mean that in 12 years we will run out of oil. More oil is being discovered every day, though it is gradually becoming harder to find. Almost without exception, the new oil found each year has exceeded the year's production. So, our proven reserves measured in barrels have continued to grow year after year. Our demand, however, has also grown.

If we look at the record over the years, we find that the ratio of proven crude reserves to annual production has fluctuated around present levels ever since the American Petroleum Institute began making annual estimates of such reserves, in 1936. Thus, reserves were about 12½ times production in 1936, about 12½ times production in 1945, and about the same ratio now. A drop below that figure apparently stiffens prices and provides additional incentive to increase the search for oil. When reserves rise above that figure, there is less incentive to drill "wildcat" wells and wells aimed at extending the present fields.

However, we must admit that the easily found oil has already been discovered. Wildcat wells must be drilled deeper and deeper to find oil. Cost goes up because of three factors: the greater number of feet drilled per well; the increased cost per foot at great depths; and today's general increase in the cost of everything. When you add those three items together, you see why wildcatting costs are soaring.

NEW OIL FIELDS

Yet we can look forward confidently to continuing discoveries. As we look at past estimates of ultimate, rather than proven, oil reserves, we find that they have always been too low, some of them spectacularly so. In 1885, the United States Geological Survey stated that there was little or no chance of getting oil in California. Since that date over 8 billion barrels of oil have been produced in that state. In 1892, the United States Bureau of Mines estimated that the total future production of the country would be only about 5.7 billion barrels. Since 1918 alone we have produced 48 billion barrels, and our proven reserves today are over 30 billion.

In 1920, the director of the United States Geological Survey said, "The United States needs foreign oil and synthetics. Peak domestic production is almost reached." But in 1955 this country's production was more than five times what it was in 1920.

As a matter of fact, even the industry experts have been too pessimistic in their forecasts. During the past 30 years some group or committee has attempted, every few years, to forecast the trend of oil production in this country; every one has concluded that the steeply ascending curve cannot continue, but must soon begin to flatten off and probably reach a peak in 10 or 15 years; but, fortunately for us all, everyone has soon been proved wrong, and there is as yet no sign of flattening.

There are many new areas in which we shall undoubtedly find additional sources. The tidelands represent a big reserve hardly suspected 10 years ago. We know there are large amounts of oil there, but it is expensive to tap.

As we learn more about reef deposits, which are hard to locate by present methods, many more will be brought in. Much more oil is being found in Canada, New Mexico, and other Rocky Mountain areas.

Not long ago representatives of The Chase Manhattan Bank presented a survey showing probable United States energy requirements in 1965—only eight years away. The estimated increases above 1955 were: total energy requirements, up 40 per cent; energy from petroleum, up 55 per cent; from natural gas, up 48 per cent; from coal, up 17 per cent. Interestingly enough, they predicted that the use of atomic energy would still be quite small.

Except for the figure for coal, which seems to me to be definitely too low in view of the scheduled expansion of central power plants, I concur generally with the bank's estimates. Certainly there is no question but that crude oil will be our main source of liquid fuels, not only for the next 10 years, but probably for several decades. It will be a major, although probably not exclusive, source much beyond that period. But what is going to happen when the discovery curve finally does flatten out? Where can we then turn for our liquid fuels?

FUTURE SOURCES OF LIQUID FUELS

We may rely on several sources. First, of course, petroleum imports will gradually increase. Second, natural gas will be more widely used, and some may be converted to liquids. The third source of liquid fuel is likely to be oil shale; the fourth, coal; the fifth, tar sands; the sixth, agricultural products; and possibly the last, air, water, and sunlight or atomic energy. Obviously, there will be considerable overlapping between many of these sources, and the latter ones are many decades or even centuries away. Just as we begin to make liquid fuels from im-

ported crude oil long before our own domestic reserves are exhausted, so other sources will come into the picture gradually as economic conditions and technological developments warrant. The moderately higher prices required to bring some of these sources into action will also promote secondary recovery, more conservation in use, and some increase in the use of gaseous and solid fuels, where such use is not too inconvenient.

There is, however, no crisis in sight that would warrant any attempt at end-use or other arbitrary control, as some of our politicians have urged. Imagine what would have happened if end-use control had gone into effect in 1920. The decision might well have been that 20 to 80 was a good ratio between oil and coal production. But if oil production or use had been controlled so that oil could be produced only in that ratio to coal, what would have happened to automobiles, trucks, tractors, and the many other gasoline-powered vehicles?

Economic factors are the best determinants as long as we have freedom of enterprise. The various alternatives for obtaining liquid fuels from sources other than domestic crude oil will come into the picture, one after the other, when economic conditions warrant, and they will take their proper place in the economy without aid from any central planning agency.

We may take a somewhat closer look at the various sources listed previously. When shortages develop, we shall almost certainly turn first to increasing imports of crude oil. Since the United States has only 6 per cent of the world's land area and only 15 per cent of the area reasonably favorable for oil accumulation, we can hardly expect to continue indefinitely our 90-year record of producing nearly 60 per cent of the world's oil. We have already dropped below 50 per cent of current free world production, and our proven reserves are today less than 20 per cent of the free world's. While imports for most of last year were greater than many of us in the domestic industry like to see, foreign oil fields are bound to increase in production more rapidly than domestic fields, partly because the percentage rate of growth of foreign demand is greater than ours. Net imports of crude oil and products have gone from below zero during World War II to an average of around 1.1 million barrels per day in the first 10 months of 1956. This is more than 15 per cent of domestic production.

Fortunately, the great bulk of all Western Hemisphere reserves and over half of the probable Near East reserves are under American control. In the last 10 years, while United States production has increased by about 1.9 million barrels a day, or 42 per cent, Western Hemisphere production outside the United States has increased by about 1.8 million barrels per day, or 145 per cent, and free-world Eastern Hemisphere production had increased by 3.5 million barrels per day, or over 500 per cent, before the Suez crisis cut it back.

Venezuela, Canada, Mexico, and the Middle East are going to be increasingly important sources of oil. The richness of some of the Middle East resources is not fully appreciated by many. While domestic American wells produce an average of 13 barrels a day, the average production in the Middle East is about 4,800 barrels per well per day. In addition, it took about 120,000 wildcats to discover the amount of reserves and producing fields in this country today. Only 200 or 300 wildcats were necessary to discover the vast amount of oil that has been found in the Middle East.

NONPETROLEUM SOURCES OF LIQUID FUELS

After imported crude oil, we may turn to natural gas, both as a substitute for, and a source of, liquid fuels. It is already quite possible to make gasoline from natural gas. But, because of the increasing field price of the gas, its fundamental worth for other purposes, and the fact that about half of the energy content is lost in conversion to liquid fuel, it seems likely that the trend will be to use natural gas directly as fuel and to convert heavy fuel oils, rather than gas, into gasoline. However, the chemical by-products of the gas conversion process may justify a few plants. Such a plant is currently in operation at Brownsville, Texas. The Fischer-Tropsch method of synthesis yields numerous by-product alcohols, ketones, acids, and the like.

Oil shale will probably come into the picture next. Deposits of this material in the United States are very large. The United States Geological Survey has just re-estimated the amount of high-grade shale available. At the present rate of consumption of liquid fuels, the shale deposits of Colorado alone would supply the country's needs for over 300 years.

The United States Bureau of Mines has done some excellent development work, which shows that mining costs can be brought lower than had been anticipated. This source presents some difficulties, however. Most of the oil shale occurs where water and housing are both scarce. Whole cities would have to be built, and water supplies would have to be developed. Improvements in retorting methods have cut down the water requirements. It now appears feasible to make gasoline from shale at not more than 20 to 40 per cent above present costs. The first use of oil shale will probably be as a source of heavy fuel oil. A certain amount of by-product gasoline and distillate fuel would undoubtedly be marketed locally if there were a demand for the heavy fuel oil at an adequate price.

Coal is another possibility. There are two processes for converting it into liquid fuels. One is gasification followed by the Fischer-Tropsch synthesis. The coal is converted into a mixture of carbon monoxide and hydrogen and then processed in much the same way as gasoline is synthesized from natural gas. The other is the high-pressure hydrogenation process.

The Fischer-Tropsch method now seems the most promising. Although the quality of the gasoline made in the early operations was low, work on natural gas conversion has shown how quality can be improved by better choice of catalysts and operating conditions. But we must remember, in any discussion of coal as a source of liquid fuels, that if we expect to get the same amount of gasoline from coal as we now get from petroleum, the coal-mining industry would have to be more than doubled. If it becomes necessary to use low-grade coal deposits for this

purpose, the industry will have to be nearly trebled. Because the deposits are very large, much larger than our proven reserves of petroleum, enlarging the coal industry by a factor of three would bring many problems.

Canada's tar sands are another possible major source of liquid fuels. But the sand must be mined, the tar extracted and then refined. This refining process presents a big problem. The tar does not contain enough hydrogen to manufacture the products needed, and the refining process itself has not been thoroughly developed. In addition, the industry would have to be located in Canada's Far West, which creates some new problems of housing and transportation.

Deriving liquid fuels from agricultural products is another long-range possibility. But we must keep in mind that, despite the politicians, this country cannot afford to use foodstuffs for conversion to gasoline. Even at the support price of $1.21 a bushel, which is well below the present market price, a gallon of alcohol from corn would cost over 60 cents, which is more than five times the present refinery price for gasoline (excluding taxes, of course). And the heat content of alcohol is only 62 per cent of that of gasoline. As a matter of fact, you could afford to pay more for corn to burn under boilers in competition with coal than you could for conversion into alcohol for motor fuel in competition with present-day gasoline. And you would save building all the expensive processing plants.

Today, we are making more than half of our alcohol from petroleum and most of the rest from molasses. It is quite unlikely that we shall, in the foreseeable future, find it economic to convert corn or other grain into alcohol for liquid fuel. There remain some real possibilities of making alcohol from some agricultural waste, where the gathering cost could be borne by some other main product. But no matter where we get it, alcohol will for many decades be too costly to be used as a motor fuel.

Perhaps the ultimate way of getting gasoline will be to start with a solar or atomic power plant. That power could be used to electrolyze water into hydrogen and oxygen. The hydrogen could be used to reduce carbon dioxide from the air to carbon monoxide, and the hydrogen and carbon monoxide could then be combined to make gasoline. However, we might find that the use of electric storage batteries charged from these sources would be cheaper, though rather too heavy for our present ideas as to car performance.

SCIENCE AND TECHNOLOGY THE REAL RESOURCE

THERE IS ONE general answer to this entire question, and indeed to most material problems. Our real future energy resource is not any substance. It is not so many barrels of oil in the ground, or even the nuclei of so many fissionable atoms. Instead, it is science and technology. If we have alert scientists and engineers, and have freedom for them to explore and develop, and if we retain the incentives for industry to put them to work, there will be no continuing shortage of any product that people really want and need.

In closing, I might mention some recent items that illustrate another important point. In the science section of a recent issue of *The Saturday Review*, Harrison Brown of California Institute of Technology describes a fascinating game. He and his scientific friends imagine that they had been given the job, about a century ago, of allocating funds for research. If the problem under study had been home lighting, they might reasonably have supported research on candles, on natural gas, and on the migration habits of whales. They could not have justified a grant to Michael Faraday or to the other pioneers whose basic research on electricity was eventually to lead to the electric light.

Important unforeseen results also come from applied research. A good example is polyethylene, the new plastic used for everything from squeeze bottles to garment bags. Is it available because a scientist started out to make a plastic? Not at all. Instead, a chemist, Dr. W. M. Burton, along about 1909 wanted to crack heavy oils to make gasoline. The research was successful. The cracking produced, in addition to gasoline, large quantities of by-product gases. At first those gases were simply burned under the refinery boilers. It was only after much basic and applied research that we now use those gases, more than 40 years later, for making polyethylene.

Any predictions for the future must take into account the great diversity of science. It may well be that our energy problems will be solved by a scientist now studying electron configurations in silicon, or even some subject considered utterly unrelated to energy.

As engineers, you are practical men, and you are so regarded by your companies. Your advice is heeded. You can do no more-constructive act than to point out to your organizations the importance and ultimate value of basic research. And, if you can help convince the politicians that freedom of research and freedom of enterprise is the real essential of continued progress, we may rest confident that engineering will not be stymied during the foreseeable future by any lack of energy sources, even though we cannot foresee with certainty exactly what they will be at a given time.

High-Speed SF_6 Switch

A new type high-speed automatic grounding switch was recently installed at the Pennsylvania Power & Light Company's Peckville substation. Developed by the Westinghouse Electric Corporation, the 196-kv switch will close on 20,000 amperes in only 5 cycles, compared to the 15 to 30 cycles required on conventional swinging-blade switches.

This switch uses a reciprocating rod instead of a swinging blade. The rod, which carries the moving contact, and the stationary contact are both enclosed in a porcelain weather housing filled with sulfur hexafluoride (SF_6) gas under pressure of about two atmospheres. The SF_6 gas permits the contacts to be placed much closer together than is possible in air.

Magnetic Amplifier Speed Control for a D-C Motor

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MAGNETIC AMPLIFIERS constitute rugged and maintenance-free elements for the conversion of a constant a-c voltage into an adjustable d-c voltage. They can be used for adjustable voltage drives of d-c shunt motors when no reversibility and no regeneration is required. The operation of a self-saturating magnetic amplifier with d-c output connected to the armature of a d-c motor is in many respects similar to that of controlled thyratron rectifiers. In both cases, the speed–torque characteristic at a fixed firing angle is not flat as with a smooth armature supply voltage, but curved at low load like that of a series motor. This is caused by the a-c content in the armature voltage and the rectifying property of the supply. In the lower power range, single-phase magnetic amplifiers offer economical advantages over polyphase amplifiers. Since for single-phase supply the distortion of the motor characteristics is most severe, economical means are required which restore the original shunt-motor characteristics.

Two solutions seem practical. By inserting a reactor of sufficient size into the armature circuit, the armature current can be made continuous, and thus the motor characteristics can be flattened. The second possibility is to establish a closed speed control loop. For the power range considered, the armature reactor is ruled out because of economic reasons and the speed control feedback loop is relied on completely.

The speed control scheme requires that the speed be measured and compared with a reference quantity. A speed signal of sufficient strength and accuracy can be obtained by compensating the armature-current drop contained in the armature voltage. A solution which is advantageous because of its simplicity and good performance is found in a small auxiliary magnetic amplifier controlled by the armature current and which provides a proportional d-c compensation voltage. This voltage can be subtracted from the armature voltage; thus, the speed of the motor can be sensed in the form of the induced armature voltage. Beside the good steady-state performance, this auxiliary amplifier has the advantage that its time delay aids to increase the damping of transients, thus improving the stability of the system.

The sensed voltage is compared with the reference voltage by voltage addition in one circuit, using only one control winding. This electric superposition is very economical because most of the reference power is converted into mechanical power in the armature. A comparison with a scheme wherein the reference and the sensed voltages are compared magnetically, using two separate control windings, shows that the electric superposition is preferable in low-gain systems because it involves only a small fraction of the losses of control power incurred in the other scheme.

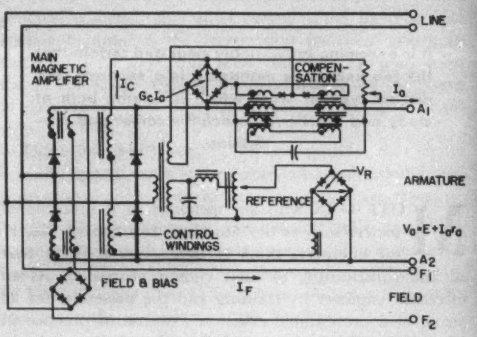

Fig. 1. Circuit diagram of a magnetic amplifier d-c motor drive.

Supply voltage fluctuations affect the speed of the motor mainly by influencing the reference voltage and the field flux of the motor. Provided that both change under varying supply voltage by approximately equal amounts, the speed will be essentially unaffected by supply voltage changes. The reference voltage must be stabilized to such a degree that its dependency on the line voltage matches approximately the saturation characteristic of the motor field. A very simple circuitry is obtained when the variable transformer, which is required for speed setting, is operated as a saturable transformer.

Fig. 1 shows the diagram of a single-phase magnetic-amplifier control circuit for a 2.5-kw drive. Its components are a standard Hipersil (registered trade mark) C-core amplifier with selenium rectifiers, a small low-gain compensating amplifier (5–10 watts) having negative feedback for good linearity and a deliberately increased time constant. The reference voltage is stabilized, as explained before. The motor field is supplied from a separate set of rectifiers. The field current serves also for bias on the main amplifier. Using this control, the speed of the motor can be smoothly controlled between full speed and standstill. The speed change between no load and full load is less than 5% at 1,200 rpm and less than 10% at 50 rpm. For varying line voltage (between 200 and 250 volts) the no-load speed deviation at 1,200 rpm is less than 3% total.

Digest of paper 57-93, "Speed Control of a D-C Motor Using a Magnetic Amplifier," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 21-25, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1957.

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A Manager's Professional Attitude

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It is becoming increasingly clear and certain that the job known as managing is a separate and distinct type of work which is worthy both of study and practice as a definite career and profession.

MOST MEN who are members of a professional society such as the American Institute of Electrical Engineers think of themselves as being part of and contributing to their chosen profession. As an electrical engineer by training and the possessor, for 20 years, of a professional engineer's license to practice in New York State, I encourage all engineering students in the colleges to join their appropriate professional societies and also to obtain their professional licenses as soon as possible after graduation. This is evidence of their sincere intent to join with fellow engineers in a lifetime effort in self-development and in contributing to the technical advancement of our society. Such associations are means through which an individual may work toward truly professional performance and the development of a professional attitude toward his work. The point to be stressed is that these are means toward desired ends, not ends in themselves. These statements are made first so as to forestall any misunderstanding or misinterpretation of the ideas presented in this article.

There is another reason for calling attention to this subject. It is becoming increasingly clear that managing is a distinct kind of work worthy of study and practice as a career and profession. Colleges give degrees in business administration and there are business societies and associations like other technical and professional societies at whose meetings business managers get together and talk shop. There is a major difference, however, between the profession of engineering and the profession of managing in that there is no serious proposal to license managers. Furthermore, any such proposal would be opposed as will be explained later.

To set the stage for this article, let us review first some of the characteristics of a profession. In briefest form these members of the profession:

1. Have a body of special, classified, organized knowledge which they continually seek to increase;
2. Encourage higher academic standards and disciplines;
3. Encourage a free interchange of new knowledge among members;
4. Strive to improve members' relations with one another, and with the public through adherence to codes of ethics (for example, "The Engineers Creed" as adopted by the National Society of Professional Engineers);
5. Recognize responsibilities to serve the entire public;
6. Encourage all members to enhance the standards of performance and the prestige of their profession by exercising leadership in professional societies, in their communities, and in all other contacts with the public; and
7. Encourage the development of a sense of responsibility in younger persons entering the profession.

In a business enterprise and in a free-market economy, the principal distinguishing characteristics of the work of the particular profession called managing are:

1. Founded upon and utilize concepts and principles, concerning the work of managing which are being progressively better classified and recorded for subsequent better understanding and use;
2. Based upon the interdependent and inseparable relationships between profitability and service;
3. Like other professions, guided by moral, social, and ethical standards of conduct which, most broadly, may be stated in the terms of the Golden Rule—"Do unto others as you would have them do unto you."

Forward looking writers have been pointing out for decades that the best practitioners of the work called managing behave in a professional manner as judged by the professional characteristics already listed.[2-11]

Because of the growing recognition, yes even assumption, that managing is a profession, it seems appropriate to explore the differences between a "Professional Attitude" and "Licensed Professionalism." In an increasing proportion of business enterprises, the manager is not the owner of the business but is an employee hired to maintain and enhance the business assets entrusted to his care and to obtain results in the balanced best interest of all who contribute to and benefit from the activities of the business.

PROFESSIONAL ATTITUDE

FIRST LET US EXAMINE the "Professional Attitude" in its most honorable and noteworthy implications. What is meant when we say, "He is a real professional?"

1. Above everything else we mean that he is consistently superior in his performance. We mean that we are complimenting the individual for possessing and using outstanding ability and proficiency leading to remarkable achievements in his chosen field of endeavor. He is out in front; he leads because he does it best, whatever *it* (his

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calling) is. Being a leader, he is self-motivated and self-disciplined (a noted musician, college teacher, surgeon, minister, ball player).

2. Next, we mean very often that actions show that the individual is wholly dedicated to his calling—he goes the "second mile[12]" as taught in the "Sermon on the Mount" and which has been pointed out by Dr. Wickenden as the mark of a professional man. Selfishness has been left behind as the individual forgets his own petty, personal likes or dislikes, hurts or inconveniences because of his compelling interest in a cause greater than himself in which he has purposefully chosen to invest his energy and ability—the minister who answers the "Call of the Gospel"; the teacher who sees the vision of service to youth; the artist who finds it impossible to resist his internal drive toward self-expression even though fame is fickle and monetary rewards are questionable; the runner, ball player, or crewman who gives until he drops, voluntarily and without reservation; the physician who goes to the aid of a patient, anywhere, any time, day or night; the actor or circus clown, "for whom the show must go on," regardless of the vicissitudes of personal life. These are all examples of men and women dedicated to their professional callings.

3. Underlying this dedication to a cause is a deeper feeling of opportunity to contribute to progress in human society, a desire to add one's bit to human progress and welfare. This is more than loyalty to clients or to a particular "professional" group. It is a deep desire often hidden because of reticence, sometimes only vaguely recognized by the individual himself, but of strong import as many young men choose their careers. It is the drive to contribute one's lifetime of effort, however great or small it may prove to be, toward adding to the total stream of human progress. This is a main motivation among professional men and particularly so as a "call" is heard by idealistic youth to train themselves to become religious leaders, teachers, researchers, doctors, and all other callings contributing directly to man's progress and welfare.

The emphasis here is that an able individual, regardless of formal training can develop within himself, as a way of life, such a professional attitude and can, through personal effort and study, become a recognized leader in his chosen profession. Thus, as an individual through excellence of personal performance, he can become recognized by his peers as a "Professional" in the best meaning of the term. One acquires dignity and inner peace when he believes that his lifetime contribution will be significant and in the direction of aiding rather than hindering human progress, when his conscious recognition of trusteeship leads to moral judgments and right use of power. One can demonstrate immortality by leaving the world better than he found it.

Many business leaders today are truly dedicated to their calling as a challenging and rewarding life which contributes directly, continuously, and simultaneously toward achieving their own personal satisfactions and also toward making this a better world in which to live. In times of peace and in times of war the strength of a nation depends upon the character, temper, and productivity of its people. By doing the managerial work which contributes directly to increasing productivity per man-hour of human effort, many business leaders know and believe that they have a vital role in the on-going progress of mankind. They are just as dedicated to social progress as men in any other calling. They have become leaders because of the recognition by their associates that they were expert in their chosen work; they have shown character, wisdom, outstandingly good judgment in decision-making; they are "tops" at the job of managing the work of others.

There are many reasons for recognizing that many business leaders already have adopted a professional attitude toward their work in the following three ways:

1. They have developed outstanding skill and have demonstrated superior performance in doing managerial work.
2. They dedicate their full energies and time strenuously to their work (in many cases too much so).
3. They recognize their obligation to society and see in their work the most challenging opportunity for contributing their bit to man's continuing progress.

PROFESSIONAL VERSUS AMATEUR

THIS CONTRAST IN TERMS has two widely accepted although also widely different meanings. First, that the professional is highly trained and outstandingly expert in his performance, whereas the amateur, whether novice or not, performs inexpertly. L. A. Appley[13] puts this contrast very succinctly as follows: "An amateur gloats over his successes. A professional is concerned over his mistakes." Second, the professional devotes his time and energy principally to the activity in question and takes pay for his performance, whereas the amateur pursues the particular activity as an avocation and does not take pay or earn his living through such performance, even though he may attain a high degree of expertness.

Managing a business enterprise occupies a manager's principal attention. It is his vocation and prime interest. He is well paid for his efforts and in most cases he must perform his managerial duties with great competence, if his business is to prosper in competitive free markets and he is to retain his job. In this sense, therefore, a manager is a professional, not an amateur.

Now let us take a contrasting look at "Licensed Professionalism."

In a British paper, the *Times' Review of Industry*, February 1955, p. 13, a special correspondent writing under the title, "Is Management a Profession?" states that "membership of a profession should be recognized by the public and the state as conferring significant status based on integrity and technical competence," and again, that "those professions which are most firmly established have some kind of state recognition," and further that "it seems indubitable that nothing so firmly supports a profession as to have a definite place given to it by law."

In reference to this statement and in direct contrast to the broad, commendable, and socially honorable "Pro-

fessional Attitude" which was detailed at the beginning of this article, let us now examine very briefly the narrowing or self-centered or restrictive practices, or abuses even, which could become associated with certain forms of "Licensed Professionalism."

Licensing does not give professional status. Rather it is recognition by a public body that at one time an individual achieved certain minimum requirements in his particular field of endeavor. Having a driver's license does not make one a good driver. Licensing is intended to be a public means for protecting the public from malpractice. It is a policing mechanism. It must necessarily set minimum rather than maximum standards which are recognized as starting points rather than ultimate goals. It is of use in producing standardized practice but it can have little influence on best practice. Licensing may even be detrimental to best practice because of the inference that mediocrity is acceptable—minimum standards are of necessity much lower than those by which the average and certainly the best practitioners live and work. Standards of performance used for licensing purposes represent merely the base from which a truly professional person starts to grow. They neither measure the potential for growth nor assure its attainment.

Detrimental rather than beneficial results will come of using "Licensed Professionalism" as a means for separating people into separate classes of managers and nonmanagers. The latter seems to be a very bad trap not only because it is socially very undesirable, but also because there are no adequate measures and standards. College degrees and advanced degrees certainly are not adequate measures because they take no account of the great areas of adult self-education represented by the continuing endeavors of an able individual throughout his entire working life. Also, using college degrees as measures would deny opportunity to able individuals who, for whatever reason, have had a limited formal education.

There is no particular class or group of people now recognized by law as professional managers. However, the public will recognize managers as professional men to the degree: (1) that there is widespread recognition of the "work of managing" as such, (2) that the theory and the elements of managerial work are written and taught and learned, and finally, (3) that people devote themselves to the study of this particular kind of work as a career, and become outstandingly proficient at doing it. Then, in imagination, we can visualize public recognition of professional status (not licensing) for outstanding managers of any activity in which groups of people direct their combined efforts toward the accomplishment of predetermined objectives.

In my opinion, licensing professional managers is undesirable and unnecessary: undesirable, because beneficial innovation might be inhibited and attention would focus on abuses, minimum standards, externally imposed policing, legal red tape, bureaucracy, and self-centered special interests and privileges; unnecessary, because in the long run, in business enterprise in a free-market economy, character, ability, and excellence in performance will win as long as there is free and open competition for managerial positions. The public already is protected from malpractice in business management by the workings of the laws of nature (science and economics) and the laws of man (justice and equity).

Evolution from Narrow "Professionalism"

"Professionalism" may be thought of as recognition by others of a special status for a particular group. In a narrow sense, concentration on business activities is sometimes carried to such an extreme that it is a fault of many business leaders. They do nothing but their jobs. They take no part in community affairs. They neglect their health, their families, and their own broad development. They get ulcers and die young. This often is evidence of deep-seated selfishness and lust for power. This fault can be corrected as each manager learns how to manage better and as his enlarging vision of social opportunity and responsibility takes the place of narrow self-interest.

In the best sense, however, managing, as a profession, does not require licensing but does require marked skill, highest quality performance and dedication to social progress in the balanced best interests of all concerned with a particular activity. It is a characterization not of a class or group of people. Rather, it is an attribute of an individual who has grown in ability so that he can make a significant contribution to his calling and his community, and who has grown in character and in mental and moral maturity, so that he has become more concerned with what he can give to his fellows than with what he can selfishly get from them. In growing from thinking in terms of restrictive "Professionalism" toward a broad morally and socially commendable "Professional Attitude," an individual sets his own standards at the highest level attainable by him and through self-education and self-discipline does not allow himself to be satisfied with simply "getting by" with minimal or unethical performance. This is evidence of the maturing of the individual from a predominantly self-centered to a predominantly service-centered attitude of mind. Insofar as each individual acquires and demonstrates outstanding ability he raises the level of public esteem not only for himself, but also for others doing the same type of work; the only valid foundation for professional recognition.

Under the heading of "Sharing the Vision: A Challenge to Leadership," Mr. Cordiner[5] closes the chapter on "Breakthrough to the Future" in his McKinsey Foundation lecture series entitled, "New Frontiers for Professional Managers," as follows:

> "Any sensitive observer must agree that the human potential in business has never been fully unleashed. The great dream of the professional manager is that some day, he will find a way to share with his associates a mutually deep vision of what a truly inspired human organization can achieve. How can he build this managerial vision on all that they, as well as he, have to contribute to its formulation? How can he help every man and woman in the organization find a sense of true participation in working toward

high and noble objectives that will bring everyone a sense of pride and satisfaction? These thoughts bring us again to that philosophy of management . . . that recognizes the freedom, and the dignity, and the capacity of each individual and eagerly asks for what he alone can bring to the organization. I am convinced that there is no such thing as the common man. Each of us is an uncommon man. Each of us has some distinctive and individual contribution that he alone can make. When the *professional manager* at every echelon of the organization recognizes this, and cherishes it as his most deeply held belief about his fellow men, then he has found the clue to leadership in the American society. It is leadership of this kind that will determine whether the way of freedom will be the way of the world."

POINT OF DECISION

FOR A VERY FEW MOMENTS, may we turn our thoughts to sociology and the world wide and history long consideration of the rise and fall of human cultural systems. Sorokin[14] in the early pages of his provocative book, "The Crisis of Our Age" says:

> "This major principle of medieval culture made it predominantly other worldly and religious, oriented toward the supersensory reality of God and permeated by this value. The major principle of the idealistic culture was partly supersensory and religious and partly 'this-worldly' and secular. Finally, the major principle of our modern sensate culture is predominantly 'this-worldly,' secular, and utilitarian. All these types —ideational, idealistic, and sensate—are exemplified in the history of Egyptian and Babylonian, Greco-Roman, Hindu, Chinese, and other great cultures. * * * the present crisis of our culture and society consist exactly in the disintegration of the dominant sensate system of modern Euro-American culture. * * * We are living and acting at one of the epoch-making turning points of human history, when one fundamental form of culture and society—sensate—is declining and a different form is emerging."

Three hundred pages later after supporting his thesis by citing history from all ages and many cultures, Sorokin summarized near the end of the book as follows:

> "At the close of the sensate periods of the past the formerly magnificent edifice began to totter. Material pleasures and comforts, utility, security, safety, and freedom progressively declined. War and other forms of strife, brutality, bloodshed, and destruction became endemic. Efforts to patch up the crumbling system invariably miscarried. Under such circumstances people could not fail to perceive eventually the hollowness of sensate culture, the hopelessness of further allegiance to sensate values, and the impossibility of attempting to preserve an orderly way of life on so rotten a foundation. . . . The destructive phase was followed by one that was constructive. * * * Religion, ethics, and law overcame the unbridled sway of force and fraud. * * * Such was the invariable course of the great crises of the past. Such is the way out of our own crisis. There is no other possibility."

With these startling thoughts in mind let us look at a possible parallelism between the sociologist's thesis of cultural evolution and a familiar businessman's plot of the normal growth curve in the life of a new product. It is common experience that sales of a new product rise toward a peak of market acceptance as saturation is approached or as competing products catch customer interest. Thereafter, a "Point of Decision" is reached in which sales of the product inevitably decline because of obsolescence unless the manufacturer incorporates major innovations of value to the customer so that an essentially new product starts up again on a new growth curve.

CONCLUSION

SUCH A CURVE can also be used to illustrate in principle the rise and fall of whole cultures. The "Crisis of Our Age" as expressed by Sorokin may be likened to the "Point of Decision" on the declining portion of a normal growth curve. The conclusion is that if our culture is not to languish and die, we must innovate, we must invent a better social structure building on the strengths and correcting the weaknesses of the past. One small step in this direction, which seems to me to be completely consistent with man's history and the process of social evolution, would be for each engineer and each manager, as a self-determining individual, to develop a professional attitude toward his work and toward his fellow workers.

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A Synthesis Method for Multipole Control Systems

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THE SYNTHESIS of multipole control systems, i.e., control systems having a multiplicity of independent inputs and dependent outputs, is one area of control engineering which, to date, has received surprisingly little attention. Such systems occur quite frequently in practice, and until recently their syntheses was feasible only through laborious trial-and-error studies with analog computers.

Because of the large number of variables which are present in a multipole control system, it is necessary to apply some constraints before a systematic synthesis may

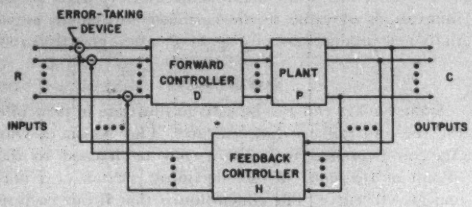

Fig. 1. Block diagram of a typical multipole control system.

be undertaken. The synthesis method described here is based on the imposition of four specific constraints, all of a very fundamental nature. These constraints are chosen to reduce the number of variables without, however, unduly restricting the freedom of the system designer. The application of these constraints permits the explicit solution of the over-all response equations for the controller transfer functions in terms of the given plant (i.e., the equipment or process to be controlled) and the specified over-all responses.

A block diagram of a typical multipole control system is shown in Fig. 1. The system consists of the plant to be controlled P, a feedback controller H, a forward controller D, and an error-taking device.

Since all the elements of the system are multipoles, the data is subjected to a series of vector transformations as it passes through the system. For this reason the solution of the system equations is most easily handled through the use of matrix algebra.

The first constraint consists of the establishment of a canonical form for multipole control systems, as shown in Fig. 2. This provides a formal basis for the synthesis procedure. Matrix partitioning is employed to separate the primary data paths (which result in control of the output variables) from the secondary data paths (which merely set system parameters).

The over-all response is given by the matrix equation

$$C = \left[\begin{matrix} \\ 1 + GDH \\ \\ \end{matrix} \right]^{-1} GDR$$

where G is related to the plant matrix P by

$$G = \begin{bmatrix} P_a & P_c \\ P_d & 1 \end{bmatrix}$$

P_a being largest possible square submatrix of P.

Coupling between the primary and secondary data paths in the feedback controller can be ruled out because it is meaningless from physical reasoning. This represents the second constraint.

The third constraint is concerned with placing certain requirements on the forward controller so that an output-noninteraction type of over-all response can be obtained.

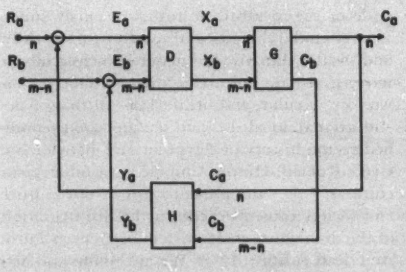

Fig. 2. Canonical form of multipole control system.

The fourth and final constraint requires that all input components be subjected to the same dynamics for any one output. In effect this implies that the feedback controller may have a zero-memory transfer function.

The application of these constraints leads to relatively simple matrix equations for the over-all response which can be solved explicitly for the transfer functions of the controller submatrices. The latter then are the design equations which permit the direct design of the controller required to achieve specified responses with a given plant.

Digest of paper 57-44, recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 21-25, 1957. Published in AIEE *Applications and Industry*, March 1957.

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Representation of Induction Motor Loads

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IN MOST POWER SYSTEM transient stability studies, the system loads are represented by shunt impedances. Commonly, the shunt impedances are treated as static impedances. This method is especially well adapted for hand calculation and for a-c network analyzer studies. It is, of course, appreciated that all loads do not behave as static impedances and methods have been developed for taking into account, more correctly, the proper variation of real and reactive power with system voltage and frequency changes. These methods have been used, where justified, in some a-c network analyzer transient stability studies.

Recently, several very large concentrations of induction motor loads have been installed on power systems. In this situation, it seems advisable during stability studies to take the load characteristics into account in a still more refined manner. Particularly, it seems necessary to take into account the load inertia of the induction machines so that the mechanical transients will be properly considered. In some cases, these transients are of equal importance to those arising from generator swings. In the case of synchronous motor loads, it is evident that they can be represented in practically the same way as the generators. In the case of induction motor loads, several representations may be used depending upon the degree of refinement desired in the representation.

One representation that can be made is to use the induction motor steady-state equivalent circuit. This permits the calculation of electrical torque at each point in a step-by-step swing curve calculation, taking into account mechanical transients, but assuming that all electrical time constants are negligible. Because of the relatively small effective rotor time constant of many induction motors, this representation is, in many cases, perfectly valid and reasonable. In some cases, however, where the induction motor rotor resistance is small or the reactance external to the motor is especially large so that the rotor effective time constant is too large to ignore, it is desirable to include also the rotor electrical transients. Certain special studies have been made that include the stator electrical transients. However, this has been shown to be unnecessary and impractical in an over-all system stability study involving several machines.

The effect of neglecting rotor electrical transients depends upon the system parameters as well as the motor constants. In order to evaluate this effect for a range of constants, a general system study was made to compare the critical switching times for a given set of conditions, as obtained using as the two methods of motor representation: (1) the steady-state equations and (2) the transient equations (neglecting stator transients). The curve from one of the cases studied is shown in Fig. 1. Previous to a general system study involving the representation of induction motors, it is desirable to estimate the error in neglecting the rotor transients. If this error is not excessive and is acceptable, the use of the steady-state equations usually allows more rapid solution of the system stability problems, particularly on the a-c network analyzer. In any case, detailed procedures which can be used to represent the induction motors either on the a-c network analyzer or in a digital computer have been developed and are in use.

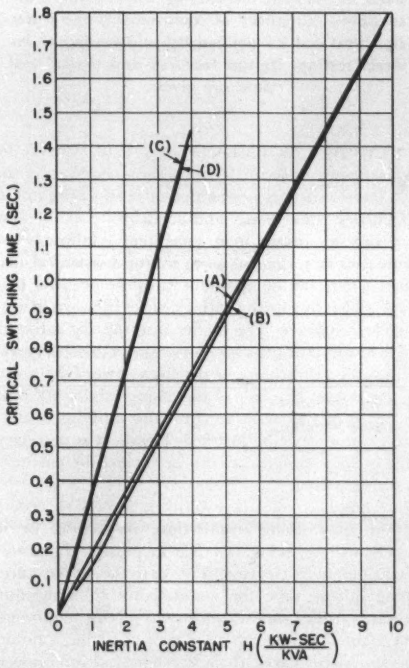

Fig. 1. Case study showing critical switching time versus the motor inertia constant.

Digest of paper 57-159, recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 21-25, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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Interrupters for High-Voltage Circuit Breakers

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The demand for higher breaker voltages and interrupting ratings created by today's expanding energy requirements presents numerous design and test problems. A new line of high-power tubular multibreak-type interrupters has been developed, features of which include accessibility, simplicity of replacement, and a design that can be verified by part-testing or indirect testing. Design features and typical test data are given.

NEW DEVELOPMENTS in a field such as high-voltage oil circuit breakers show the effect of many factors such as power system needs, available testing facilities, convenience and accessibility of the device, and a very important item, consistent relation between various sizes or ratings so as to secure economical manufacture. There can be no doubt as to the need for higher voltage and interrupting ratings, since they are being demanded everywhere. The higher interrupting rating does introduce a serious problem, however, in exceeding by far the limits of a direct test in any high-power laboratory of reasonable size. The cost of increasing laboratory output by a factor of two or more runs into millions of dollars which cannot easily be justified. Hence, it is necessary to have a breaker design that can be verified by part-testing or indirect testing.

More emphasis on accessibility is always in order, so that the man doing installation, inspection, or field checking will be aided as much as possible in restoring the equipment to service. The extreme importance of keeping outage time for maintenance to a minimum, occasioned by the almost continuous service requirements of the limited number of lines now available, cannot be overemphasized. Parts which are removed for inspection should be so constructed that they can be returned to normal operation with no realignment problem. The condition of parts which may erode or wear in service should be easily determined, although their service life is considered unsatisfactory unless it borders on the "unlimited."

A family group of interrupters has been brought out to meet all these basic requirements and also to utilize common parts in varying multiples as the voltage rating of the breaker changes. All sizes are built into a tubular insulating chamber mounted on one of the two condenser bushing terminals per pole. Separating finger-type contacts draw short arcs within interrupter blocks which vent symmetrically to each side of the tube. These blocks are the building units from which the line is constructed —one block for a 69-kv chamber assembly, two for 161 and 230 kv, and four for 330 kv.

ORIGINAL DEVELOPMENT

THE NEW TUBULAR MULTIBREAK TYPE of interrupter was first developed to help meet the demand for a circuit breaker having a rating of 25,000 mva at 330 kv. The maximum fault current of 46,000 amperes at a line-to-ground voltage of 190 kv exceeded by many times the power for verification available in any existing high-power laboratory. The need for a multibreak device permitting unit testing was dictated by these requirements and resulted in the 4-break unit previously described before the Institute.[1,2,3] With uniform voltage distribution provided across the several breaks, the proportionate voltage per unit is slightly more than 22 kv, a test voltage at which full rated symmetrical fault current is readily available. Uniform voltage distribution across so many gaps is assured by the use of grading means comprising capacitor and resistor units tapped in across each break.[3]

Fig. 1 shows schematically the essential features of the 330-kv interrupter. It consists of a heavy-walled tube made of insulating material and containing the finger and moving contact components which provide the several breaks. A block built up of glued and dowelled fiber plates is inserted through close-fitting holes in the wall of the tube in the region of each break and affords the structure required to effect rapid extinction of the arc. An oil-driving piston located at the upper end of the tube provides forced oil flow through the orifices and out the vents of each fiber block to assist in the interruption of lower-valued currents. The entire interrupter unit was designed to permit removal from the tube those parts subject to erosion by the arc such as contacts and fiber blocks without loss of inherent contact adjustment and alignment. This feature has proved to be of considerable value in the matter of time savings during breaker maintenance.

An extensive series of tests was made in the high-power laboratory on a full pole, half pole, and also a single break, all at proportionate voltages to the maximum power available. Typical data are included in Table I.

The data obtained on the single-break tests are of considerable interest inasmuch as they form the basis for the

Essentially full text of paper 57-178, "New Line of High Power Interrupters for Breakers Rated 69 Kv and Above," presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 21-25, 1957. Recommended for publication by the AIEE Committee on Switchgear. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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design of the other multibreak units developed for the lower voltage ratings described later in this article. Fault-interrupting tests at 22 kv to a maximum of 49,000 amperes demonstrated the ability of the fiber block structure to interrupt very high values of fault current with an average arcing time of less than 1 cycle. The oscillogram of this test is shown in Fig. 2. As shown in Table I, interrupting tests at 44 and 66 kv on the single break to the maximum power of the laboratory further demonstrated a wide range of voltage-interrupting ability.

Momentary current withstand tests to 70,500 amperes (rms) and 4-second current withstand tests to 48,000 amperes proved the adequacy of the contact structure for carrying extremely high values of current. Normal continuous current-carrying ability of the multibreak type of interrupter to 2,000 amperes was demonstrated by thermal tests to meet ASA (American Standards Association) and NEMA (National Electrical Manufacturers Association) Standards which limit the temperature of current-carrying parts to a rise of 30 C above ambient. The chimney effect upon thermal convection currents in the oil provided by the tubular structure with open check valve top and bottom is an important factor in keeping the temperature rise within limits, even at 2,000 amperes. During an opening operation, the check valves are forced shut by the pressure developed within the tube by either the pump or the arc.

A considerable number of these 330-kv 25,000-mva breakers have been in service on the customers' systems for several years. Fig. 3 shows one such installation. The excellent operating performance and relatively trouble-free experience shown by these breakers has proved the basic design principles of the multibreak interrupter to be sound. The ease with which the interrupter blocks and contact assemblies can be removed from the interrupter tube for examination was demonstrated graphically recently when, after a series of line-dropping tests, the oil was drained from all three poles of the breaker and the interrupter parts removed and examined within a period of approximately one hour total time.

Table I. Typical Opening Tests on 330-Kv Interrupter

Test Voltage, Kv	Maximum Interrupted Current for the Series, Amperes	Per Cent Rated Interrupted Current (25,000 Mva)	Average Arcing Time for the Series, Cycles	Equivalent 3-Phase Mva *
Full Pole (8 Breaks)				
396	3,750	8.5	1.3	4,450
Half Pole (4 Breaks)				
198	6,000	13.6	0.8	7,100
154	8,200	18.6	0.6	7,600
110	11,300	25.7	0.9	7,500
88	15,300	34.8	0.75	8,100
44	30,600	69.7	0.7	8,100
22	49,000	111.0	0.7	6,500
One-Eighth Pole (1 Break)				
66	20,800	47.3	1.0	33,000
44	22,500	51.0	1.0	29,700
22	49,000	111.0	0.7	25,800

*Equivalent 3-Phase Kva $= \frac{3 \times \text{Test Voltage (Kv)} \times \text{Interrupted Current}}{\text{Fraction of Pole Tested}}$

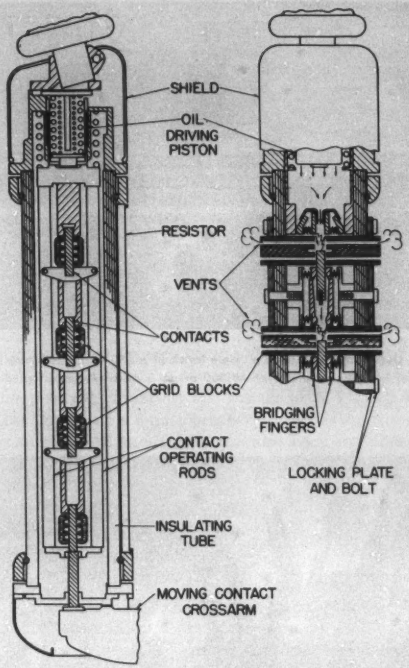

Fig. 1. Schematic cross-sectional drawing of 330-kv 25,000-mva multibreak tubular interrupter, showing essential design features.

Several of these breakers in the field have been exposed to both fault-interrupting and line-switching operations. Automatic oscillograph records of one line disturbance resulting in breaker opening showed that the breaker successfully interrupted nearly one half the rated 25,000 mva. As reported previously,[2] one of these breakers was tested at the Dearborn Substation of the Ohio Valley Electric Corporation system to determine its performance on line-dropping operations. A total of 103 three-phase opening operations were made involving 42, 114, and 185 miles of line. The interruptions were completely restrike-free and the breaker performed very consistently.

SECOND STEP: 230 KV, 15,000-20,000 MVA

THE EVER-INCREASING CONCENTRATION of system loads at 230 kv over the past few years has created a demand for breakers having interrupting capacity in excess of 10,000 mva. It would appear that the next logical step could be a breaker having a rating of 20,000 mva. The feasibility of this step was shown by the excellent test data obtained on the 330-kv breaker in the laboratory and on the customer's system. The data obtained on a single break at voltages up to 66 kv verified the practicability of using an

Fig. 2. Oscillogram of test on a single break of a 330-kv 25,000-mva interrupter in which a current of 49,000 amperes (rms) was interrupted at 22 kv.

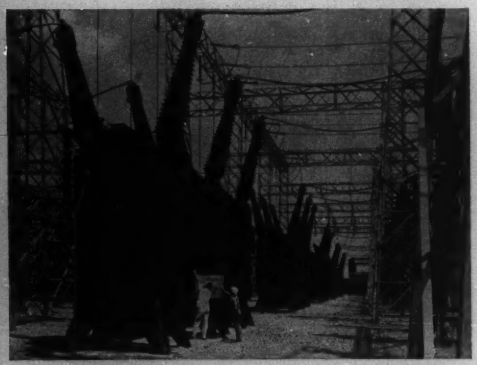

Fig. 3. Installation of five type-3300GW25000 oil circuit breakers at Ohio Valley Electric Corporation, Kyger Creek Station, Ohio.

Fig. 4. Oscillogram of high-speed single-reclosing duty cycle with 22 kv applied to one 161-kv 15,000-mva interrupter. Reclosing time is 15 cycles.

interrupter unit for 230 kv, having two breaks each. The proportionate voltage of 33 kv per break is well within the interrupting capability of the interrupter block and contacts used in the 330 kv design. This was verified in the high-power laboratory by the comparable performance obtained on tests on a 230-kv interrupter consisting of two breaks. Successful charging current tests at 83 kv on a half-pole unit over a range of currents from 15 to 215 amperes were made with control over the tripping of the breaker to provide all possible relations of the instant of contact parting to current zero. This 2-break interrupter was also tested extensively to maximum values of fault current equivalent to more than 20,000 mva, 3 phase. Typical data are presented in Table II.

It is expected that although present requirements are for breakers having interrupting ratings of something less than 15,000 mva, the demand for breakers capable of interrupting 20,000 mva will arise within the next few years. It is reassuring to know that such a rating is practicable.

APPLICATION AT 161 KV, 15,000 MVA

A PAPER recently presented before the Institute[4] describes the development and design of a 161-kv 15,000-mva breaker equipped with multibreak type of interrupters also similar to those used on the 330-kv breaker. These interrupters have two breaks each, making the proportionate voltage per break about the same as that for the 330-kv design. The extreme concentration of load on a large 161-kv system created the demand for breakers of such a rating. Fault-interrupting test data are shown in Table III.

Of interest was the special requirement for the breaker to be capable of making a single reclosing operation at maximum current without derating, and multiple reclosing with only a slight reduction in rated ability. These requirements were met as demonstrated by tests made on a single interrupter at 22 kv. Figs. 4, 5, and 6 show oscillograms of single, double, and triple reclosing operations. These data are summarized in Table IV.

The momentary and 4-second current withstand ratings for this breaker exceeded those required for the 330-kv unit. A momentary current test of 91,000 amperes with an initial crest value of 150,000 amperes shown on the oscillogram in Fig. 7 and a 4-second current withstand test of 59,000 amperes demonstrated the ability of these contacts to meet these requirements. An indication of the excellent condition after these tests of the fingers, moving contacts, and dashpot from the cross-arm is shown in Fig. 8.

One of the design requirements imposed on the 161-kv multibreak interrupter was that it fit into existing 161-kv 10,000-mva breaker tanks with a minimum of change in over-all design. This was accomplished in such a manner that it is possible to revamp existing 161-kv 10,000-mva breakers in the field with these interrupters, and uprate the interrupting capacity to 15,000 mva by doing so. Considering the large number of breakers having the former rating now in service, the value of being able to

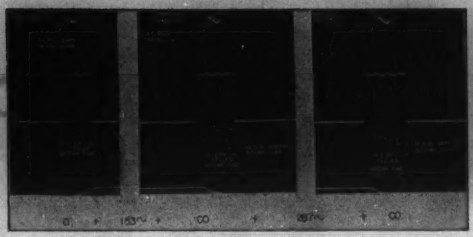

Fig. 5. Oscillogram of double-reclosing duty cycle on a 161-kv 15,000-mva multibreak interrupter with 22-kv test voltage. Reclosing times are 15.3 and 28.7 cycles, respectively.

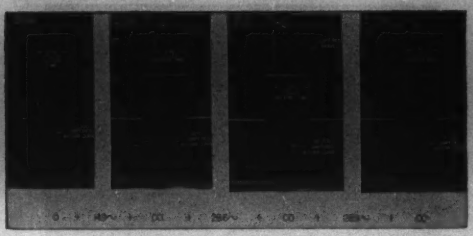

Fig. 6. Oscillogram of triple-reclosing duty cycle on a 161-kv 15,000-mva multibreak interrupter with 44-kv test voltage. Reclosing times are 14.9, 28.6, and 28.9 cycles, respectively.

uprate to 15,000 mva cannot be overemphasized. Fig. 9 shows an installation of two breakers of this rating.

The design and general dimensions of the 161-kv grids are such that they could also be used in 115- and 138-kv breakers having 10,000-mva interrupting ratings without any significant change in breaker over-all dimensions from those now available.

BASIC SINGLE UNIT APPLIED TO 69 KV, 5,000 MVA

THE ESSENTIAL FEATURES of the higher-voltage interrupter designs were incorporated into a single interrupter unit for use in a breaker having a rating of 69 kv, 5,000 mva. For this rating, the proportionate voltage per break is less than the laboratory test voltage of 22 kv. Fig. 10 is a photograph of a 3-pole breaker of this rating on test. The single-break interrupter has also been incorporated into a frame-mounted type of breaker for an interrupting rating of 3,500 mva at 69 kv.

The interrupter for this voltage rating differs only slightly from those developed for the higher ratings. In this design, the pump for effecting interruption of low-valued currents is located at the lower end of the tube.

Table II. Typical Opening Tests on 230-Kv Interrupter

Test Voltage, Kv	Maximum Interrupted Current for the Series, Amperes	Per Cent Rated Interrupted Current (15,000 Mva)	Average Arcing Time for the Series, Cycles	Equivalent 3-Phase Mva *
Full Pole (4 Breaks)				
198	5,300	14.1	1.05	3,150
132	7,200	19.2	0.95	2,850
Half Pole (2 Breaks)				
132	7,200	19.2	1.15	5,700
66	15,000	40.0	1.15	5,930
44	24,200	64.6	1.05	6,400
22	64,500	172.0	0.80	8,500

*Refer to Table I.

Table III. Typical Opening Tests on 161-Kv Interrupter

Test Voltage, Kv	Maximum Interrupted Current for the Series, Amperes	Per Cent Rated Interrupted Current (15,000 Mva)	Average Arcing Time for the Series, Cycles	Equivalent 3-Phase Mva *
Full Pole (4 Breaks)				
198	5,300	9.8	1.0	3,150
132	9,100	16.9	0.75	3,600
88	18,500	34.2	1.0	4,880
22	58,100	108.0	0.7	3,850
Half Pole (2 Breaks)				
44	32,500	60.2	1.1	8,570
22	58,000	107.5	0.65	7,650
One-Fourth Pole (1 Break)				
22	56,500	104.5	1.0	14,900

*Refer to Table I.

Table IV. Reclosing Tests on 161-Kv Interrupter (Half Pole—2 Breaks)

Test Voltage, Kv	Interrupted Current, Amperes	Per Cent Interrupted Current (15,000 Mva)	Arcing Time, Cycles	Equivalent 3-Phase Mva *
Open – 15.7 Cycles – Close – Open				
22	58,000	107.5	0.5	7,670
	49,000	91.0	1.0	6,490
Open – 15.3 Cycles – Close – Open – 28.7 Cycles – Close – Open				
22	44,500	82.2	0.8	5,880
	34,600	64.0	0.85	4,580
	34,600	64.0	1.05	4,580
Open – 14.9 Cycles – Close – Open – 28.6 Cycles – Close – Open – 28.9 Cycles – Close – Open				
44	27,300	50.7	0.85	7,200
	19,700	36.5	1.05	5,200
	20,200	37.5	1.8	5,320
	19,700	36.5	1.1	5,200

*Refer to Table I.

Table V. Typical Opening Tests on 69-Kv Interrupter

Test Voltage, Kv	Maximum Interrupted Current for the Series, Amperes	Per Cent Rated Interrupted Current (15,000 Mva)	Average Arcing Time for the Series, Cycles	Equivalent 3-Phase Mva *
Full Pole (2 Breaks)				
88	18,100	43.0	1.2	4,780
44	35,800	85.2	1.0	4,740
35.2	54,000	128.0	1.0	5,700
Half Pole (1 Break)				
22	48,000	114.0	1.1	6,360

*Refer to Table I.

Fig. 7. Oscillogram of a momentary current withstand test on a 161-kv 15,000-mva interrupter at 91,000 amperes.

on breakers of higher voltage ratings incorporating the tubular type of interrupter.

The rapidly increasing growth of metropolitan areas, many of which are served by 69-kv transmission systems, has created a demand for breakers having fault-interrupting capacities of 3,500 and even 5,000 mva. The increased demand for breakers of this rating makes it desirable to equip them with interrupters having the features incorporated into the active higher voltage ratings. A cross-

Fig. 9. Installation of 1610GM1500 oil circuit breaker on system of Tennessee Valley Authority.

In other respects, such as the fiber block and the size of the contacts, the interrupter is the same as those previously described.

A complete series of tests was made in the laboratory on both the 3,500- and 5,000-mva breakers. Typical interrupting data obtained on these interrupters are given in Table V. These data check closely with those obtained

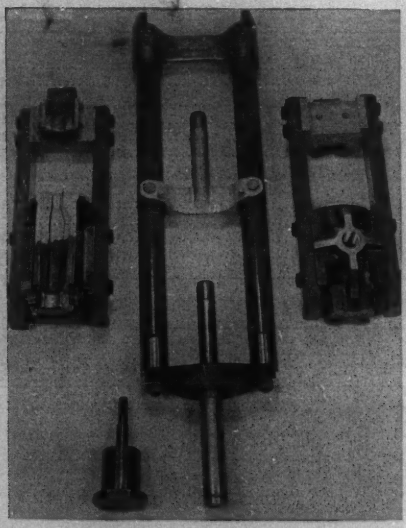

Fig. 8. Photograph showing excellent condition of fingers, captive contacts, and cross-arm dashpot of 161-kv 15,000-mva interrupter after momentary current withstand test of 91,000 amperes and a 4-second test of 59,000 amperes.

Fig. 10. Type-690GM5000 floor-mounted oil circuit breaker on test in the factory.

sectional view of the 69-kv interrupter is shown in Fig. 11. Its close family relationship to the higher voltage designs may be noted by comparing this figure with Fig. 1, which shows a cross-section of the 330-kv interrupter.

CONCLUSION

THUS, IT IS APPARENT that the fundamental interrupter block can be tested adequately for performance, is han-

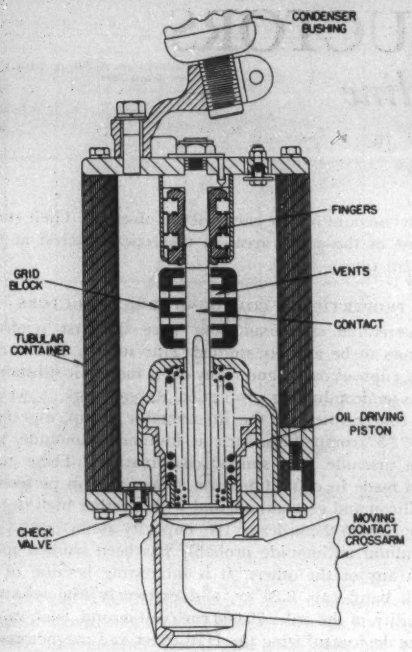

Fig. 11. Schematic cross-sectional drawing of 69-kv 5,000-mva tubular interrupter, showing essential design features.

dled easily during inspection, and can be used readily in multiple as the voltage rating is increased. Applications from 69 kv to 330 kv inclusive (one to four units) are already in service, and tests show that additional units will operate equally well at higher voltages.

Mechanical loading on the breaker mechanism is principally that of accelerating the moving parts to get the desired breaker opening speed, inasmuch as sliding contacts are used with each break.

Accessibility with resultant reduced breaker outage time is an outstanding feature, permitting direct visual examination of all contacts and their mechanical alignment when the interrupter blocks are removed, with the knowledge that no change in adjustment occurs when they are replaced for service. Likewise, should the duty on the breaker cause erosion of the fiber plates over a period of years, there is an opposite face to be turned up for increasing the service life before replacement becomes necessary.

Tests show this interrupter block to give ideal performance up to a rating in excess of 50,000 amperes. This corresponds well to the needs of the industry at several voltages, becoming 5,000 mva at 69 kv; 15,000 mva at 161 kv; 20,000 mva at 230 kv; 25,000 mva at 330 kv, etc.

At this interrupting level, the basic 69-kv 50,000-ampere unit can be shown by direct test in the high-power laboratory to have all the requirements of a modern breaker in ease of operation, speed of interruption, small amount of burning of oil, minor contact depreciation, reliable performance even on charging and magnetizing current, moderate mechanical burden on the mechanism, and hence long and economical life.

As a component used alone at 69 kv or in multiples of four at 330 kv, and possibly at still higher voltages, this design provides a family of interrupters, similar in ampere rating, proved by existing laboratory facilities. Economical manufacture naturally follows, and simplicity of parts provides a large measure of convenience during maintenance.

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3. Control of Voltage Gradients in High-Voltage Watch-Case Multibreak Oil Circuit Breakers, B. P. Baker, R. E. Friedrich. AIEE *Transactions*, vol. 75, pt. III, June 1956, pp. 286-92.

4. A New Top Rating for the 161-Kv Oil Circuit Breaker with Multibreak-Type Interrupters—15,000 Mva, G. J. Easley, F. L. Reese. AIEE *Transactions*, vol. 75, pt. III, Apr. 1956, pp. 58-63.

Reactor Component Checkout

A final checkout of the control rod drive assembly for the 50-kw solution-type research reactor being built by Atomics International, a division of North American Aviation, Inc., for the Japan Atomic Energy Research Institute is made by company technicians. The final shipment of reactor components, which included this assembly, left the United States for Tokyo recently.

SEMICONDUCTORS
An Outline

W. C. DUNLAP, JR.
MEMBER AIEE

In this second section of a two-part article, the properties of compound semiconductors and the structure and preparation of p-n junctions are described. The fields of application of semiconductors are summarized, with indications given of the probable direction of future developments in each of these fields.

THE CONDUCTION PROPERTIES of silicon and germanium have been rather thoroughly studied during the past few years. The properties are summarized in Table I. Figs. 14 and 15 also show the temperature dependence of the resistivity and Hall coefficient of p-type germanium.

Table I. Summary of Conduction Properties of Silicon and Germanium

	Silicon	Germanium
Band gap, ev (0 degrees Kelvin)	1.21	0.76
Dielectric constant	11.7	15.8
Temperature dependence of mobility		
Holes:	$T^{-2.6}$	$T^{-2.1}$
Electrons:	$T^{-2.6}$	$T^{-1.6}$
Intrinsic resistivity, ohm-cm (298 degrees Kelvin)	5×10^5	47
Room temperature mobility, cm²/volt-sec		
Holes:	400	1,900
Electrons:	1,300	3,800

Among the properties most actively studied recently have been the effects due to various impurities in both silicon and germanium. Of particular interest is the occurrence of multiple states, of which gold in germanium is the best example. Gold has been shown to have five possible ionization states in germanium, ranging from Au^+ through Au^o up to Au^{---}. In filling up these levels with electrons, energy states are added from the valence band to the conduction band, as shown in Fig. 15. The Au^+ state results from the donor action of the gold in giving up its one valence electron, whereas the multiple acceptor levels arise from the bonding action of the gold to fulfill the bonds of the germanium lattice.

Although silicon has not been so thoroughly studied, it appears that similar, though not identical, properties will also be found.

In none of the deep states does the simple hydrogen model account for the energy levels observed. Their study is one of the active areas of theoretical interest at the present time.

PROPERTIES OF COMPOUND SEMICONDUCTORS

COMPOUND SEMICONDUCTORS were the first semiconductors to be actively studied. Zinc sulfide, silicon carbide, cuprous oxide, and many other inorganic substances have semiconducting properties. Recent work, however, has concentrated on the intermetallic group, especially the "3-5" compounds, such as indium antimonide, gallium arsenide, and similar combinations. These have been made in crystalline form comparable in perfection to silicon and germanium, and with a rather high degree of purity (to the order of 10^{14} impurity atoms/cm³).

Indium antimonide probably has been studied more than any of the others. It is interesting because of its small band gap, 0.20 ev, and extremely high electron mobility, of the order 70,000 cm²/volt-second. Such values make devices utilizing the Hall effect and magnetoresistance quite promising. However, associated with the small band gap is a high intrinsic conductivity and strong dependence of the conduction properties upon temperature.

An active area of study in semiconductors is that of infrared photodetection, and for such studies indium antimonide is of great interest, because it shows an intrinsic photoconduction out to about 5 to 6 microns of wave length, again because of the small band gap.

Indium antimonide also has been of interest recently because of the occurrence of the "magneto-optical" band effect, which is analogous in some ways to the Zeeman effect, as it occurs from a direct effect of magnetic fields upon the possible electronic states.

The nature of the impurity centers in indium antimonide is now under investigation, but the results are not as well established as for germanium. Lattice defects, of which more varieties are possible than for the monatomic crystalline semiconductors, may include lattice vacancies of both components, as well as interstitials of either component. In addition, there are more possibilities for donor and acceptor action by the substitutional replacement of either component by a foreign atom.

As the properties of the antimonides in particular become better studied, attention tends to range to other intermetallics, and to ternary compounds.

Most of the classical binary compounds, such as zinc sulfide or cuprous oxide, cannot be prepared to the same

Part II of a two-part article, presented as a paper at the National Electronics Conference, Chicago, Ill., Oct. 1-3, 1956, and recommended for publication by the AIEE Committee on Solid State Devices.

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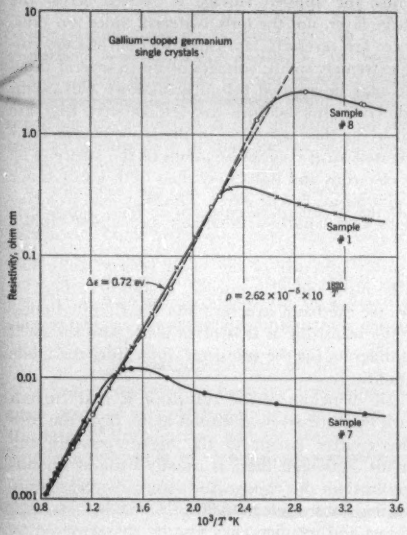


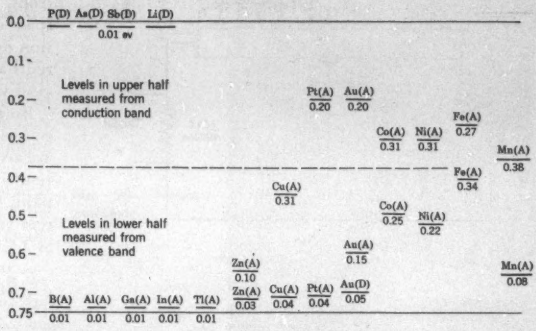


Fig. 14 (left). Resistivity, p-type germanium. Fig. 15 (above). Impurity states in germanium.

degree of purity or homogeneity as other compound semiconductors, with the result that more detailed and reproducible information about these materials has been obtained in the last few years in the antimonides than during many previous years of study of the oxides and sulfides. Much of the basic work in the field of semiconductors, however, was done with these oxides.

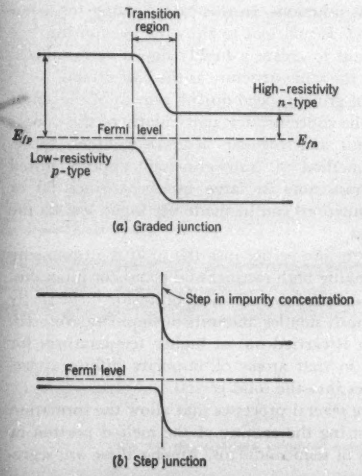
The compounds offer the promise of a wider range of properties than the monatomic materials, which number only seven or eight, and indeed, of these only silicon and germanium, and possibly tellurium and selenium, offer immediate promise of successful application.

Such compounds as silicon carbide, for example, with its large band gap of about 3 ev, offer promise of high-temperature applications for rectifiers and transistors.

Within the last few years, an increasing number of other compounds have been prepared in pure single crystal form. Among these are lead sulfide, lead telluride, cadmium sulfide, zinc sulfide, zinc oxide, and bismuth telluride. Better values of such parameters as band gap, temperature dependence and absolute value of carrier mobilities, and carrier lifetimes have been obtained with these materials. This field forms one of the most active areas of semiconductor research.

P-N JUNCTIONS AND THEIR PREPARATION

ALTHOUGH THE BULK PROPERTIES of semiconductors are of great fundamental interest, and of considerable importance in some applications, many of the most interesting applications depend upon the presence of the p-n



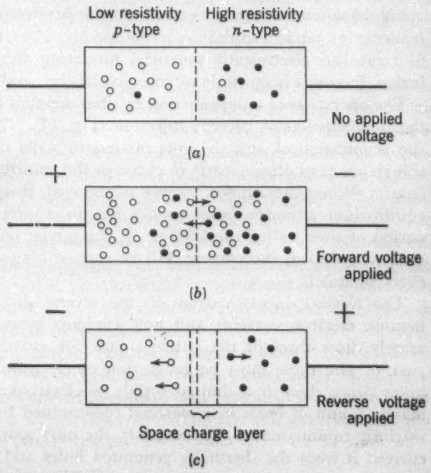


Fig. 16 (left). Band picture of p-n junction. Fig. 17 (right). Elementary picture of junction rectifier.

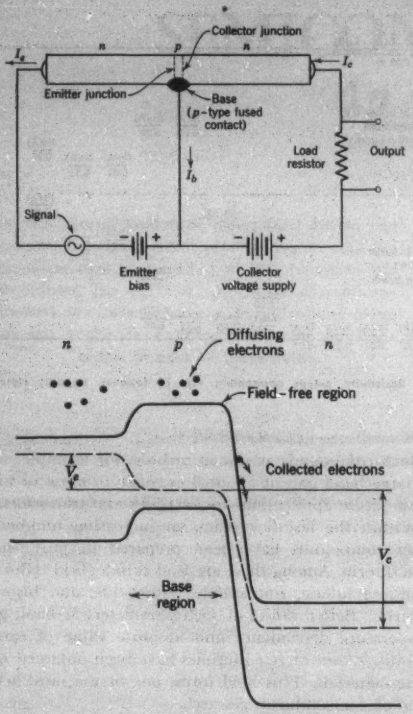


Fig. 18. Structure of junction resistor.

junction, a surface separating the p- and n-portions of a semiconductor. Rectifiers, photocells (most of the important phototransistors and photovoltaic cells), and transistors depend upon the presence of the p-n junction.

Fig. 16 shows the band structure of a p-n junction. The tendency of carriers to diffuse across the boundary tends to create an electrostatic potential hindering this diffusion, having a magnitude often equal to the band gap.

The operation of a p-n junction rectifier depends upon the phenomenon of current injection (Fig. 17). This is the penetration of, say, the hole carriers into the n-type side in amounts often greatly in excess of the equilibrium density. When the applied voltage is removed, this non-equilibrium situation may persist for an appreciable period of time, called the lifetime. If the p-type portion is heavily doped, the current will be carried almost entirely by holes.

The rectifier blocks current in the reverse direction because electron currents and hole currents must, separately, flow through the entire circuit for current to pass, or else there must be generation of electrons and holes. Since there is a limited supply of electrons in p-material, and of holes in n-material (determined by the intrinsic conduction in the material), the only source of current is from the thermally generated holes and electrons. Thus, the applied voltage is exerted across the space charge layer, not the bulk material. Since p-n junction devices are carefully fabricated so that leakage currents are extremely small, voltages of up to several thousand volts may be applied before breakdown will occur.

Breakdown occurs because the few carriers that are generated by thermal agitation in the space charge layer are accelerated until they ionize atoms in the lattice. The resulting electrons and holes may then both ionize other pairs, to give an avalanche effect. This may lead to a current varying very rapidly with voltage, perhaps as rapidly as V^{23}.

A transistor structure of the usual variety, more specifically the n-p-n model transistor, is shown in Fig. 18. There, we see the basic structure and the circuit connections for the transistor as it is often used. Also shown is the band diagram for the transistor, indicating the mode of operation.

The basic principle of the transistor is that current carriers are transported by diffusion alone from the low-impedance emitter circuit to the high-impedance collector circuit. Although there is usually little or no current amplification, the voltage and hence the power amplification may be as high as 10,000.

Transistors and rectifiers may also be characterized by the manner in which they are prepared. The technology of making p-n junctions and transistors is a rapidly advancing field of semiconductor studies at the present time. Among the most important techniques of preparing junctions are the following:

1. "Doping" during growth of the crystal. By adding the proper type and amount of impurity during growth of the single crystal, successive p-n junctions can be made. Usually, only one pair of p-n junctions is made per ingot, although repetition is possible.

2. Fusion of the opposite type impurity in the form of a metallic contact is a widely used method of making junctions. For germanium, indium on n-type germanium makes the best junctions. In this case, heating for a few seconds at 600 C is sufficient to alloy the indium into the germanium, and to create a highly doped recrystallized region having the same structure as the base crystal.

3. Change of growth speed during growth of the single crystal alters the concentration particularly of the donors present without affecting the acceptor content appreciably. This method of "rate growing" appears suited for making transistors in large numbers, since 50 or more sets of junctions can be made per ingot, unlike the doping method.

4. Diffusion of impurities into the solid is a promising method for making both rectifier and transistor junctions. The method differs from alloying or fusion principally in that very much smaller amounts of impurity are used, and treatment is carried out at higher temperatures for longer times, so that atoms of impurity diffuse appreciable distances into the solid crystal.

5. There are several processes that allow the formation of junction during the cooling of the melted portion of a bar or plate of semiconductor. Among these are segre-

gation effects, in which the different initial concentrations of donor and acceptor combine with the varying concentrations along the growing ingot, so as to produce a junction. A second is the "meltback," or "melt-quench" method, which is, at least to some extent, a modification of rate growing. In this method, rapid cooling leads to much the same effect as in rate growing, and the donors tend to predominate in that portion of the bar cooling the most rapidly.

6. Junctions can be made by various bombardment techniques, such as ion bombardment or nucleon bombardment. These techniques have not, as yet, led to devices having particular promise for applications.

7. Vapor-deposition of doped germanium upon a single crystal base by decomposition of a volatile halide, such at GeI_4, is a promising technique now being studied.

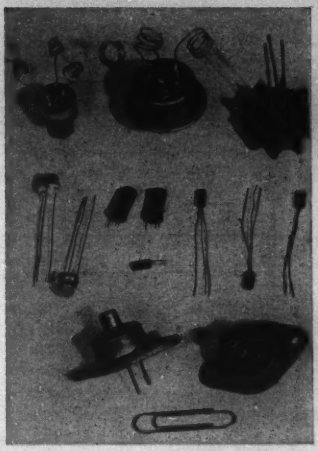


Fig. 20. Junction transistors.

SEMICONDUCTOR DEVICES

IN THIS CONCLUDING SECTION, the applications that have been made of semiconductors will be summarized, and the level of development and the probable direction of future development of each will be indicated.

1. Rectifiers. Rectifiers are probably the oldest application of semiconductors, beginning with the lead sulfide detector crystals, and the cuprous oxide power rectifiers developed during the 1920's.

Rectifiers are of two general types—point contact and area rectifiers. The point-contact types rectify, even though the nature of the contact at the two sides of the semiconductor is the same. The nonlinearity of the voltage–current curve then accounts for the rectifying property. In area rectifiers, the area of contact to the semiconductor is the same, but the nature of the contacts is different on the two sides.

During the 1920's and 1930's, the most important rectifying materials were cuprous oxide, cuprous sulfide, and selenium. These are all commercially important today, but germanium and silicon are rapidly overtaking them and will almost certainly become predominant during the next few years. The higher degree of designability and understanding associated with these materials, their better uniformity, reproducibility, and, of great importance, their high efficiency (germanium) and high-temperature response (silicon), account for the trend to germanium and silicon rectifiers.

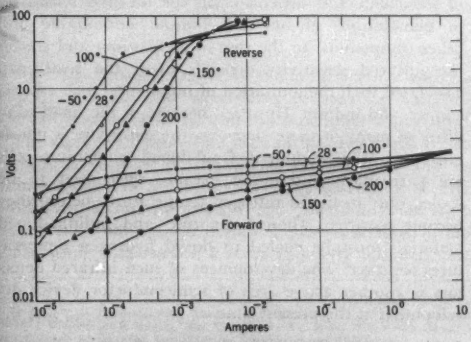


Fig. 19. Characteristics of silicon rectifier.

Germanium and silicon point-contact rectifiers are widely used for high-frequency rectification and detection because of their small capacitance and high efficiency.

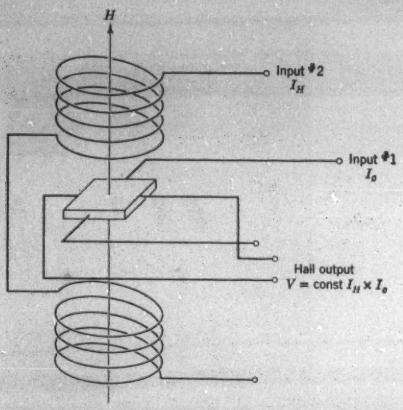
Semiconductor power rectifiers have capabilities for current up to hundreds of amperes per square inch, and voltage ratings up to several thousand volts per cell. Power capabilities are increased by forced cooling by air or water, and by combinations of series and parallel connections.

Fig. 19 shows the forward and reverse characteristics of a typical small silicon rectifier at various temperatures.

2. Transistors. Transistors are characterized not only by the material involved and by the power and frequency range, but also by the structure used, of which there are several types.

a. The point-contact transistor, the original model, is used but little nowadays. Although it was expected to have application in the high-frequency range, above 100 mc, even in this range junction transistors are preempting the field. The point-contact transistor may be made in one of several ways: (1) A pair of fine whiskers may be placed within a few mils of one another on the face of a pellet of germanium. These are the emitter and collector. The base is an ohmic contact to the wafer itself. (2) The whiskers are placed on opposite sides of a thin 1- to 4-mil wafer. (3) The whiskers are placed at the edges of a thin wedge.

b. Junction transistors such as those illustrated in Fig. 20 have been made in the power range all the way from a few milliwatts to tens of watts. There appears to be no upper limit to the power that may be achieved, with proper design.



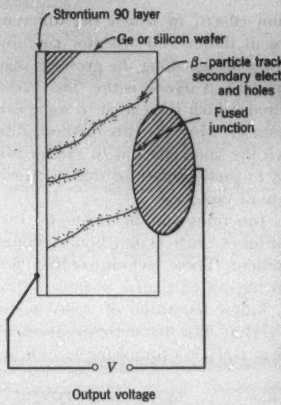


Fig. 21 (left). Hall amplifier. Fig. 22 (right). Atomic battery.

c. Most important of the widely used structures is the triode, which is the basic structure. The tetrode is a modified triode, having an extra base contact for passing an auxiliary current through the base and for reducing base resistance and increasing frequency response into the hundreds of megacycles.

d. Still another important structure is the p-n-i-p structure. This is a triode transistor with an intrinsic layer between base and collector designed to reduce collector capacity and to reduce transit time of carriers between emitter and collector without cutting collector voltage breakdown unduly. Such transistors have operated well above 1,000 mc in experimental units.

These transistors may all be made by any of the techniques outlined for making p-n junctions. The diffusion process, in particular, is widely under study at the present time, since large-area transistors with extremely thin base thickness (1 to 5 microns) are easily made. However, practically all of the millions of transistors now on the market are still being made by the fused-junction method.

Other mechanisms for transistor action are being studied. Among those not depending upon carrier injection are the unipolar transistor, which depends upon the space-charge layer widening effect of a reverse voltage applied to a p-n junction. Experimental units applying this model have been made, but little further development has resulted.

3. Hall Effect and Magnetoresistance Devices. Other semiconductor amplifiers are possible, besides those called transistors, which by definition involve p-n junctions. Among these are Hall-effect and magnetoresistive amplifiers. In both these types, a magnetic field is essential.

In the Hall-effect amplifier, a high-mobility crystal such as indium antimonide is required. The signal is applied to a solenoid or similar arrangement for producing the magnetic field. The output is obtained from the Hall electrodes of Fig. 21. Although appreciable power may be obtained, frequency response is low because of the large inductances usually required.

In the magnetoresistance type amplifier, the amplifier action is through the direct valve action of the magnetoresistance effect upon the current flowing through the sample. Again, the action can only be obtained with high mobility materials, which are also those having high magnetoresistance.

4. Photocells and Solar Batteries. P-n junctions have the important property of being able to produce a photo-emf when illuminated by light. This photovoltaic effect is the basis for many widely used photocells. It may also be the agency for eventual efficient transfer of solar energy into electrical energy. However, with silicon-fused or diffused-junction cells, the highest efficiency obtained to date is about 8 per cent.

Similar effects are produced when junctions are irradiated by nuclear particles (Fig. 22). Such atomic batteries are less efficient, however, than solar batteries, and the damage from the radiation soon reduces the efficiency still further.

Semiconductors also show the property of photoconductivity and some of the most interesting applications of semiconductors depend upon the infrared sensitivity of germanium, silicon, and indium antimonide and other compounds. In the case of germanium and silicon the infrared sensitivity depends upon the small gap associated with the ionization of impurities, such as zinc, copper, and indium. However, because of the small solubility of many of these elements, the sensitivity is not as great as would be desired. Gold-doped germanium cells are particularly interesting because they need to be cooled only to liquid nitrogen temperatures before they become sensitive, whereas the zinc- and indium-doped materials must be cooled to liquid hydrogen temperatures or lower. The development of such infrared detectors is another active area of semiconductor device development at the present time.

5. Thermistors. The basic property of semiconductors,

mainly that they have a negative temperature coefficient of resistivity, is also being used in commercial application. Thermistors, or thermally sensitive resistors, are now used in a wide variety of applications such as liquid-level meters, thermometers, control devices, compensating resistors, and as elements in oscillators. The most widely used thermistors consist of beads or plates made by firing at high temperature mixtures of various oxides such as nickel, copper, and manganese.

Sensitivity of these elements is generally of the order of 1 to 5 per cent per degree C. The greater the sensitivity, the greater are the problems associated with stability and reproducibility.

There are other types of thermistors having much larger changes of resistance with temperature which depend upon the occurrence of a phase transition. Silver sulfide, for example, is a compound whose resistivity changes from 10^5 to 1 or 2 ohms at the temperature of 177 C. However, problems of speed of response and stability are such that a satisfactory silver sulfide thermistor for commercial application has yet to be developed.

SUMMARY AND CONCLUSIONS

THE BASIC PROPERTIES and the device applications of semiconductors have been discussed in a very general way. The entire field has matured to a degree, but fundamental new changes are still to be expected. In many basic areas, such as the theory and experimental basis of the band structure of many important semiconductors, there is also much important work to be done. The theory of the impurity atom energy levels is still in the process of development. The properties of compound semiconductors are in the stage of development, as purer and better crystals of these substances are obtained.

The engineering of semiconductor devices still presents a challenge to designers and development engineers. A relatively few types of transistors have been successfully reduced to commercially sound products, partly because of uncertainties in the nature of semiconductor surfaces and means of controlling them. These problems combine those characteristics of metallurgy and chemistry, and those of quantum mechanics and solid-state physics.

Electronic Fault Analyzer for Transmission Lines

H. E. McCORMACK
MEMBER AIEE

The problem of locating sustained faults on transmission lines depends on a number of factors such as speed, accuracy, cost, and the final results. A pulse-type, electronic fault analyzer is used in the Appalachian system because of the mountainous topography. Method of use and results of tests and experiences are detailed.

ALL POWER COMPANIES are concerned with the problem and procedures of locating sustained faults on transmission and even lower voltage lines. The method or procedure used in locating faults is generally determined by the speed, accuracy, cost, and the final results. In past years, airplane patrolling of overhead conductors has been widely practiced. Probably in most cases, the age-old tried and proved method of foot patrolling transmission lines is generally followed. The chief reason for installing sectionalizing switches has been to aid in locating and isolating faults.

In general, the transmission lines on the Appalachian system traverse a varied topography, covering elevations from approximately 600 feet above mean sea level (msl) to approximately 4,000 feet msl. This condition makes foot patrol very difficult, slow and costly, and handicaps utilization of airplane patrol, particularly over mountainous sections or during storms that cause line trouble. Unless faults can be located quickly and accurately, customers will suffer long outages, and revenue will be lost.

Over the past several years there has been considerable discussion and thinking about the use of a reliable fault finder, and possibly a more accurate indication of ice formation on conductors. The ice formation is particularly significant on the Appalachian system as only a few miles of a line section across the mountain peak may be at the icing elevation.

The southeast section of this system, with Roanoke at the approximate center is of particular concern since service is completely dependent on transmission facilities.

Essentially full text of conference paper 57-148, "Test and Experiences in the Use of Pulse-Type Electronic Fault Analyzer on Transmission Lines," presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 21-25, 1957. Recommended for publication by the AIEE Committee on Transmission and Distribution.

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FAULT TESTS AND ICE DETECTION PROCEDURES

In the summer of 1955, a line fault analyzer, model No. *124*, manufactured by the Sierra Electronic Corporation, was put under test and use on this system. The use of the pulse-type electronic fault finder is not particularly new and several other similar methods of locating disturbances on power lines are in use.

The instrument consists of a high sensitivity oscilloscope, a linear variable-sweep generator and a pulse generator synchronized with the oscilloscope screen. A 1,000-volt pulse of 1-microsecond width is applied at the start of the sweep. Sweep ranges with full scale of 5, 25, 50, and 100 miles and sweep delayed ranges of 5 to 25 miles and 20 to 100 miles are provided. It is understood that this device is connected to the transmission line on the secondary side of the normal communication or relaying capacitors. If fault checking is to be carried out on lines not equipped with capacitors, some type of auxiliary capacitors protection or high-current drainage coils is required.

When a line is in trouble, the oscilloscope screen readings are checked against the normal pattern. If the fault is a short circuit or a ground or the impedance is lower than normal, the pulse deflection appears as a dip below the base line, or if the fault is an open circuit or the impedance is higher than normal, the deflection results in a pip above the base line, indicating the approximate location of the fault as determined by the sweep mileage marker.

It is necessary in all cases that the line be de-energized before connecting the instrument, and normally all disconnects are opened before the instrument is connected to the carrier terminals. It is possible and desirable to read with the opposite terminal disconnects closed or air break switches closed in order to pick up an adjacent section for checking, which must also be de-energized. Another operating procedure adopted is that the test readings by the analyzer must be made when all personnel are clear of the line; in other words the instrument cannot be connected to the capacitor terminals when dead line clearance is in effect on the circuit.

Frequently, the testing must be done under inclement weather conditions. A light wood platform has been devised for the instrument to rest across an automobile front seat top and longer leads supplied to protect the instrument and permit the operator to take his readings during rain or snow storms.

A series of staged tests were made on the 132-kv lines terminating at the Hancock and Roanoke 132-kv stations. The purpose of these tests was to produce a normal pattern of each line as it appears on the oscilloscope screen of the instrument, so that line crossings, tap stations, or any condition that would cause a change in the continuity of the impulses could be distinguished from a fault (Fig. 1).

In tests carried out at different intervals the impulse pattern of each line was plotted and two different commercial photographers were used to photograph the oscilloscope screen. The pictures of the screen were only fair because obviously the deflection at any given moment was recorded, whereas an individual acquainted with operation, spending some time observing the screen and patiently drawing the deflection patterns, will eliminate any transient deflections not associated with a normal line pattern.

Several tests were carried out at the Hancock station using the Glen Lyn—Hancock 132-kv line after a normal pattern (Fig. 2) of the line was read and plotted for future reference. The first staged test was with all three phases grounded at tower 11 out of Glen Lyn, with the oscilloscope showing plainly the location of the fault. Then a test was made with the No. 3 or top phase open at tower 11 which was also very distinct on the screen, with the analyzer reading 47.50 miles to the point of fault compared with the actual line mileage of 48.4 miles, a difference of 0.9 mile. Additional experiments were carried out using tower 152 on the same line (Fig. 3).

TESTING THE 132-KV NETWORK

On March 22, 1956, a test was set up using the Claytor

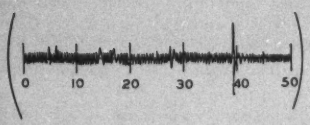


Fig. 1. Normal pattern of the Claytor—Roanoke 132-kv line as seen from Roanoke.

Fig. 2. Normal pattern of the Glen Lyn—Hancock 132-kv line as seen from Hancock.

Fig. 3. Glen Lyn—Hancock 132-kv line with loop open at tower 11 near Glen Lyn.

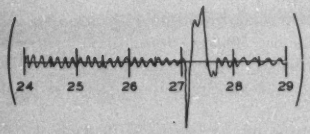


Fig. 4. Pattern of fault on the Claytor—Roanoke 132-kv line at tower 111, 28.24 miles from Roanoke.

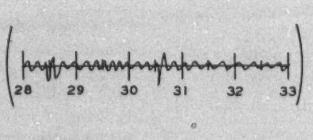


Fig. 5. Pattern of fault on Claytor—Roanoke 132-kv line at tower 120, 29.92 miles from Roanoke.

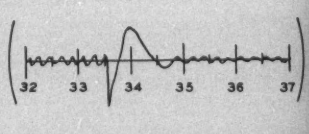


Fig. 6. Line fault pattern of Claytor—Roanoke 132-kv line at tower 139, 34.00 miles from Roanoke.

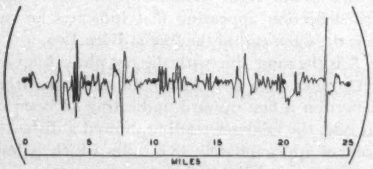
to Roanoke 132-kv line and special clearance arrangements were made with the normal communication channels not in use so that the testers would be entirely unaware of crew activities and location of test faults.

The top conductor on tower 111 was grounded and the analyzer read 28.0 miles on the 0 to 50 mile scale, and on the delayed sweep (0 to 5 miles) the indication was 27.0 to 27.5 miles with the deflection indicating a ground. The actual line mileage from Roanoke is 28.24 miles (Fig. 4).

Then, the ground on the top phase was removed and the middle phase grounded at tower 120 which is a distance of 29.92 miles from Roanoke. The analyzer read on the wide screen 30.50 miles to the fault, and the delayed sweep showed approximately the same distance, indicating the fault 2 miles beyond the Christiansburg tap which was correct. In this case, the deflection was downward indicating a ground and the fault location was within 0.58 mile of the actual distance (Fig. 5).

The ground was removed on tower 120 and the bottom phase was grounded at tower 139, a distance of 34.00 miles from Roanoke. The analyzer indicated a distance of 33.5 miles on the wide scale, and the delayed sweep indicated 33.0 to 33.5 miles. The accuracy in this case being 0.5 mile (Fig. 6).

In each of these three tests, readings were made from No. 1 phase and No. 3 phase and, as noted, the middle phase fault was indicated, although capacitors are not connected to this phase. A fault on the middle phase indicated a much narrower deflection than the other two



4.1 MI. = RAILROAD CROSSING AT KELLEYS CREEK.
4.12 MI. = KELLEYS CREEK TAKE OFF AT CEDAR GROVE.
4.4 MI. = 330 KV. CROSSING.
7.4 MI. = HUGHESTON STATION
8.4 MI. = LONDON SWITCHING STATION
18.3 MI. = GAMOCA
23.5 MI. = OPEN LINE AT GAULEY MT. STATION.

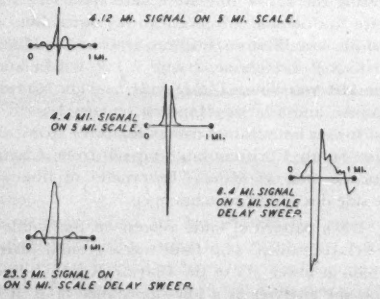

4.12 MI. SIGNAL ON 5 MI. SCALE.
0
1 MI.
4.4 MI. SIGNAL ON 5 MI. SCALE.
8.4 MI. SIGNAL ON 5 MI. SCALE DELAY SWEEP.
23.5 MI. SIGNAL ON ON 5 MI. SCALE DELAY SWEEP.

Fig. 7. Normal line pattern of No. 1, 44-kv Cabin Creek–London line, Gauley Mountain Station as seen from Cabin Creek.

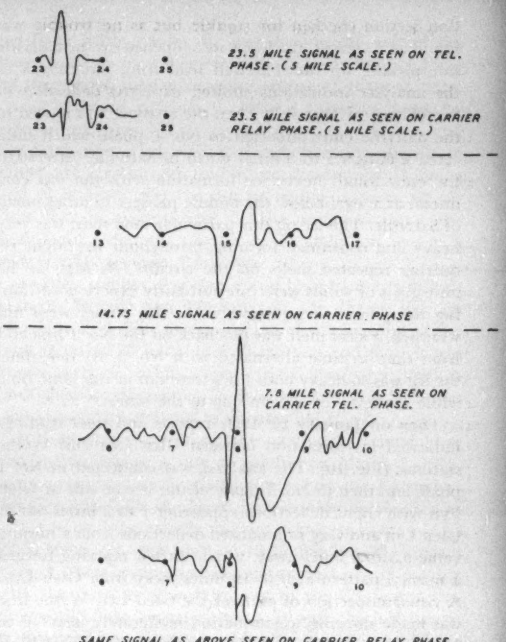

23.5 MILE SIGNAL AS SEEN ON TEL. PHASE. (5 MILE SCALE.)
23.5 MILE SIGNAL AS SEEN ON CARRIER RELAY PHASE. (5 MILE SCALE.)
14.75 MILE SIGNAL AS SEEN ON CARRIER PHASE
7.8 MILE SIGNAL AS SEEN ON CARRIER TEL. PHASE.
SAME SIGNAL AS ABOVE SEEN ON CARRIER RELAY PHASE
NOTE: 8.1 AS SCALE READING INSTEAD OF 7.8 MI.

Fig. 8. Test series on a 44-kv network using three line sections with the intermediate terminals bypassed.

phases; and the type of fault, whether an open circuit or a ground, may be questionable on the screen indication. Reading from this phase makes it quite necessary that a normal pattern of the line be available for comparison.

In addition to the tests on the 132-kv lines, one series of tests was made on a 44-kv network using three line sections with the intermediate terminals bypassed. The purpose of these tests was to determine the value, if any, of this type of fault finder on a congested system not only with parallel lines but with low voltage networks adjacent to the line in test throughout most of its length (Figs. 7, 8).

CHECKING ICING CONDITIONS

DURING APPROXIMATELY ONE YEAR'S USE of this analyzer, the system has been comparatively free of sustained faults; however, starting on January 11 through January 14 of 1956, icing conditions were experienced at intervals over several sections of the system. On January 13th, the No. 1 Switchback–Saltville 132-kv line opened automatically indicating a fault following a sleet melt. The fault analyzer was first used on the Switchback end picking up the deflection caused by the Tazewell station and also a much lesser indication of a fault on the Saltville end approximately 3.5 to 5 miles from Saltville. With no normal pattern of the line, the testers had the Tazewell sta-

tion section checked for trouble but as no trouble was found at Tazewell, the loops were opened on the Saltville side picking up the Tazewell load from Switchback as the analyzer indications showed expected deflection of Switchback to Tazewell. Then the analyzer was moved to the Saltville end connected to No. 1 phase which indicated a fault 4.5 to 5 miles north of Saltville. Afterward the crew found heavy ice formation with the top conductor at a level below the middle phase 4.75 miles north of Saltville. The ice on this particular mountain was very heavy and continued forming throughout the night requiring repeated melts on the circuits. As high as 40-mile gusts of winds were intermittently experienced causing the phases to go together. As the phases were not wrapped, a sleet melt was put back on the No. 1 line and from time to time alternated with No. 2. At one time, the ice was so heavy both lines were out at the same time while changing over from one to the other.

Then on January 20, 1956, reports and sleet readings indicated ice formation between Glen Lyn and Wythe stations, (Fig. 10). The analyzer was connected to No. 1 phase and then to No. 3 phase of the Wythe line at Glen Lyn with slight deflections appearing 1 to 2 miles out of Glen Lyn and very pronounced deflections from a normal value 5.5 to 6 miles away, which started tapering toward a normal pattern at 9 to 10 miles away from Glen Lyn. A visual inspection of parts of the Glen Lyn–Wythe line was made showing ice formation moderately heavy 6 to 11 miles out of Glen Lyn. At 7.5 miles or the top of Wolf Creek Mountain on the north side, the ice was about 2 inches in diameter. The Holly Brook side of this mountain range was clear of ice except that the high points had light coating. It should also be noted that a line under construction on these towers had a heavier coating than the energized circuit.

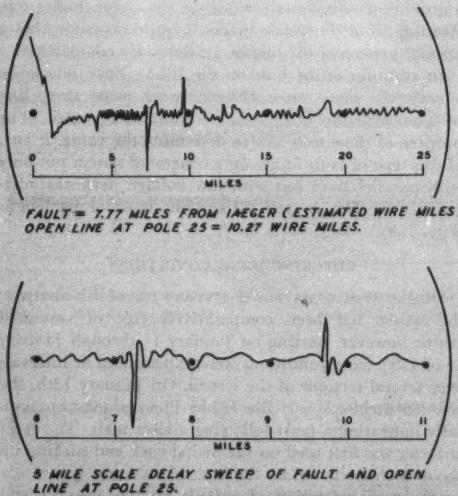


Fig. 9. Coalwood 88 kv-Iaeger Tap with switches open at pole 25 and fault at 2.5 wire miles from pole 25.

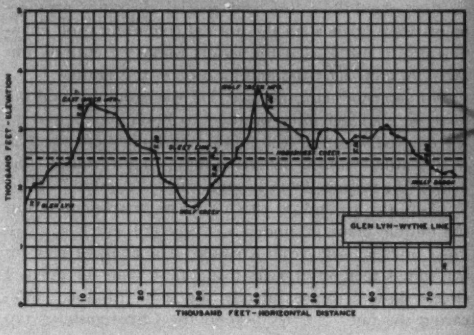


Fig. 10. Profile of portion of Glen Lyn–Wythe 132-kv line.

In July of 1956, a sustained fault developed on the 88-kv system between Iaeger and Coalwood, W. Va. The analyzer was connected on the Iaeger end picking up the ground fault with a phase down 7.7 miles away as shown in Fig. 9.

DETAILS OF TESTS AND EXPERIENCES

THE PLOTTED oscilloscope screen record in Fig. 2 shows the Glen Lyn–Hancock line reading from the Hancock end on the 0 to 50 mile scale of the analyzer connected to phase No. 3. The right terminal of the screen with the upward deflection appearing first indicates an opening which is the open end of the line at Glen Lyn.

Fig. 3. is the same line with the top phase loop open at tower 11 out of Glen Lyn. Again, the departure from normal deflection is first upward, indicating an open circuit. In this case, the analyzer reading showed a distance from Hancock of approximately 48.5 miles which is less than 1-mile of the actual line mileage.

In Fig. 1 a normal pattern for the Claytor–Roanoke 132-kv line is shown on the 0 to 50 mile scale of the analyzer screen. These points of interest may be noted:

4.7 Miles—The Hancock station take-off for the Claytor–Hancock and Hancock–Roanoke lines; *5 Miles*—Crossing the 132-kv line are 8 wire Western Union, 7 wire Norfolk and Western Railway signal line, and Norfolk and Western Railway tracks; *6.7 Miles*—2 wire C & P Telephone, 2 wire A.E.P. 6.9 kv and 2 wire 110 volt line; *17.5-18.5 Miles*—The Claytor–Roanoke and Claytor–Hancock circuits leave common towers for separate towers for three spans; *28.5 Miles*—South Christiansburg tap-off from Claytor–Hancock line; *39 Miles*—Claytor end of line with line side disconnect switches open.

Fig. 4 is a pattern of fault as seen on the 5-mile scale using delayed sweep. This fault was a ground placed on top phase at tower 111 of the Claytor–Roanoke line and read on the analyzer as a low impedance fault at 27 to 27.5 miles from Roanoke.

Fig. 5 shows two points of interest on this 5-mile scale

using delayed sweep. At 28.5 miles is the South Christiansburg station tap-off from the Claytor–Hancock line. At 30.5 miles is a fault consisting of ground placed on middle phase of the Claytor–Roanoke line at tower 120 at 29.92 miles from Roanoke.

The bottom phase of the Claytor–Roanoke line was grounded at tower 139, 34.00 miles from Roanoke, and Fig. 6 represents a 5-mile scale pattern of this fault using delayed sweep. This fault was read as low impedance fault at 33.5 miles from Roanoke.

Fig. 7 shows a plotted pattern for normal conditions of these approximately 25 mile line sections. In Fig. 8 are shown (*top*), the readings of the first tests with the ground on the first pole adjacent to the terminal end, reading at 23.5 miles; (*center*), the results of the second test showing the fault 14.75 miles away; and (*bottom*), the third test on the 44-kv network, reading 8.1 miles away whereas the actual line mileage was 8.42 miles.

In Fig. 9 the 88-kv line had been sectionalized at pole 25 or an actual mileage of 10.27 miles from Iaeger, at which point the readings were being taken. The analyzer picked up the ground fault distinctly 7.77 miles away or 2.57 miles from the open switch at pole 25. The actual mileage from pole 25 to the point of trouble is 2.5 miles.

A section of the Glen Lyn–Wythe line, shown in Fig. 10, that was checked for sleet formation with the analyzer is typical of the elevations encountered through our 132-kv system in the mountainous sections of West Virginia and Virginia where often only mountain peaks are in the icing temperature levels.

VALUE OF RAPID FAULT DETECTION

THE VALUE OF THIS FAULT FINDER will be in the time saved locating the sustained fault, the avoidance of opening loops while testing the line and, in the case of tap stations, an accurate determination in order to open loops on the correct side to expedite service to these stations. As an example, on July 9, 1955, a sustained fault developed on the 132-kv circuit between Claytor and Fieldale; after loop sectionalizing, restoring service to Floyd, the location of trouble was determined 15 hours and 42 minutes later. In this particular instance we believe that an average time for the testers to locate the fault from either the Claytor or Fieldale end within a mile would have been 2.5 hours.

Another comparative case would be the sustained fault between Hazard and Pineville on the 154-kv line on March 1, 1954. The determination of the location of the fault required 20 hours and 30 minutes and then it was known only to within a space of 12 structures. With a fault analyzer in service in that section, this 20 hours could have been reduced to about 5 hours.

Still another example of time saving that could have been made, was in a case of trouble on March 5, 1955, with a sustained fault at structure 41 on the Kanawha–Bradley line. This line went into trouble on the 5th at 4:20 p.m. and the trouble was not definitely located until 12:00 noon the next day or 19 hours and 40 minutes later. A liberal estimation in locating this case of trouble with the instrument working out of the Charleston section would have been two hours. If only the instrument at Roanoke had been available, the trouble could have been located by 9 p.m. that same night or approximately five hours later.

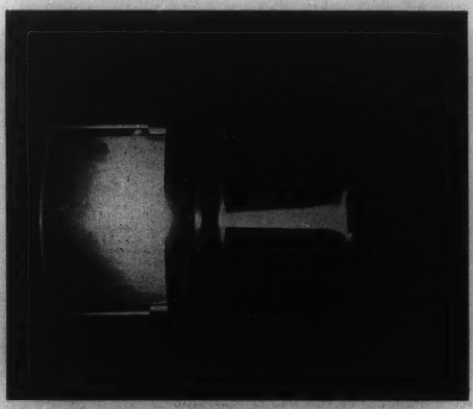
In most cases, the location of the fault within 1 mile will have been determined before the crew is able to reach either terminal; consequently, considerable crew travel time can be saved by rerouting.

Atomic Vapor

The fourth state of matter, the substance of the stars, is being produced by the General Electric Company's Missile and Ordnance Systems Department in their Aerosciences Laboratory.

Key instrument in producing this substance is a water-stabilized arc. A water-stabilized arc differs from a conventional electric arc in that the arc column is controlled, or stabilized, by a whirling blanket of water around the arc. The water gives a "squeezing" effect, forcing the column to stay within prescribed limits and allowing more and more current to flow across the arc points with correspondingly increased temperatures and higher velocities.

The water-stabilized arc has allowed the creation of the highest technically useful temperatures yet achieved on a continuous basis. The highest verified temperatures measured thus far have been 14,000 Kelvin or 25,660 F. For comparison, the surface temperature of the sun is 6,000 Kelvin, or 11,260 F. These temperatures are brought to bear on objects by a plasma stream, or jet,



flowing at high velocities from the arc through a nozzle in one of the electrodes.

A Predicted Wave Signaling Phase-Shift Telegraph System

E. T. HEALD

R. G. CLABAUGH
ASSOCIATE MEMBER AIEE

Increasing communication demands by Government, business, and industry emphasize the need for an advanced conception in communications. Since radio and carrier spectra are limited, Collins Radio has concentrated on improving system performance. The technique of predicted wave signaling using kinematic filtering is discussed in connection with multiplex systems.

A PREDICTED WAVE signaling (PWS) communications system[1] accepts at its input either synchronous or asynchronous telegraph or synchronous business machine data. With conversion, the system will accept binary information from any source. The transmission system utilizes optimum detection techniques permitting improved performance in the presence of noise. The distant output, accordingly, provides signals suitable for asynchronous teleprinting or synchronous data processing equipment.

A series of binary choices representing possible business machine or telegraph codes is transmitted wherein the following information is known by the detector before the arrival of the incoming pulse: (1) arrival and completion time, (2) pulse shape, (3) frequency and spectrum, and (4) possible data content.

Highly stable mechanical resonator filters in the detection equipment are turned on and off in step with the arrival and conclusion of each incoming signal pulse. This ability of the detector to predict (hence, predicted wave signaling) the incoming pulse insures that only during intervals when the incoming signal is present will the detector be subjected to noise. It is mainly this characteristic which permits superior performance in the presence of noise.[2]

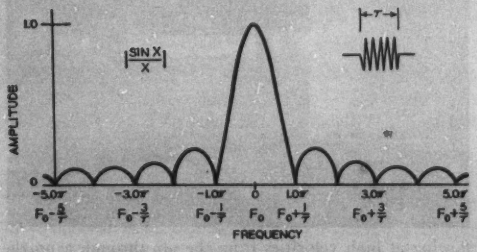


Fig. 1. Frequency response of a keyed resonator filter.

The keyed detector filters are held open for T seconds and permit adjacent tone spacings as close as $1/T$ cycles.[2,3] The detector opening interval, T, as represented in Fig. 1 is, respectively, for 45, 55, or 75 bit-per-second operation: 18.2, 9.1, or 9.1 milliseconds, permitting tone spacings of 110 cycles. Note that 60, 75, and 100 words per minute asynchronous telegraph speeds correspond, respectively, to Kineplex system speeds of 45, 55, and 75 bits per second per channel. Whether the system is employed for the transmission of binary business machine or asynchronous "start–stop" telegraph data, it must utilize one of these speeds.

Fig. 2 is a Kineplex tone-frequency allocation. As shown in this figure, 20 tones are employed, each involving two channels with center frequencies ranging from 605 to 2,695 cycles with a synchronizing tone placed at 2,915 cycles. Allowing for approximately 500 cycles of guard against unfavorable delay at band extremities, a total bandwidth of approximately 3,300 cycles is employed. This represents a two-to-one improvement in bandwidth efficiency over comparable frequency shift keying (FSK) systems. Operation in bandwidths several hundred cycles narrower is possible, providing delay characteristics are favorable. Even though twenty 150 bit-per-second tone channels are each spaced 110 cycles apart, adjacent channel crosstalk can be held to approximately 40 decibels below on-frequency response.

The distant receive equipment employs a time base, the phase of which is held in step with the incoming signals by means of the transmitted 2,915 cycle synchronizing tone. This tone is on–off modulated at the transmitter such that its demodulated envelope can be phase compared at the receiver with a similar locally generated pulse, from which phase corrections are imposed on the receiver time base to maintain receiver timing within a suitable margin.

Synchronizing tolerances of ± 1.9, ± 4.5, and ± 2.2 milliseconds, respectively, are permitted for 45, 55, and 75 bit per second per channel operation. These values are the tolerable differences of delay permissible between the data tones, individually, and the sync tone. The over-all delay response of the transmission medium between a Kineplex transmitter and distant receiver is generally held within these margins.

Fig. 3 is a block diagram of a duplex transmitting and receiving terminal showing only four channels. The terminal, as shown, is equipped for 60 milliampere tele-

Essentially full text of paper 57-65, recommended by the AIEE Committee on Telegraph Systems and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N.Y., Jan. 21-25, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1957.

E. T. Heald and R. G. Clabaugh are with the Collins Radio Company, Burbank, Cal.

printing inputs and outputs. Shift registers may be employed in place of code converters and keyers to make use of the entire 40 channels serially at a maximum capacity of 3,000 bits per second. In this form, the system is employable for the transmission of business machine data.

ASYNCHRONOUS CODE CONVERSION

A CODE CONVERTER effects conversion of the 60, 75, and 100 word-per-minute start–stop telegraph code to a 7.0 code compatible with the Kineplex synchronous transmission system. The code converter is a single level storage and direct "read-out" device and has built-in protection against false starts, the durations of which are defined as less than one quarter of one bit interval.

PHASE-SHIFT GENERATION

TWO CHANNELS of binary information are associated with each tone generator. For Kineplex telegraph employment, therefore, two code converters or shift-register outputs are common to each tone generator as shown in Fig. 3. The mark-space outputs of both code converters, or the associated shift register, are transformed at the generator such that the phase shift between successive tone generator output pulses is either zero or 180 degrees for a channel defined as the "in-phase channel," and 90 or 270 degrees for the "quadrature channel." Considering four possible combinations of two code converter outputs, the resultant phase shifts between successive generated pulses, therefore, are 45, 135, 225, and 315 degrees as indicated in Fig. 4.[4]

At the detector, both channels are rendered mutually independent by a 90-degree rotation of each stored pulse before quadrature channel detection and by defining as

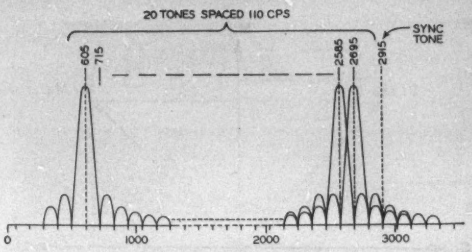


Fig. 2. Tone frequency allocation.

zero the detector output of either channel for "pulse-to-pulse" phase shifts of 90 or 270 degrees.

Each generator output pulse, therefore, possesses an angular phase position with respect to the pulse immediately preceding it, the value of which is dependent on both generator inputs. Fig. 5 is an oscillographic representation of the generator output showing it to be a series of discrete bit-length sine waves, the frequency of which is accurately determined by a highly stable mechanical resonator oscillator.

COMMON EQUIPMENT

THE COMMON EQUIPMENT consists of the combining and distributing units. As shown in Fig. 3, a combining unit accepts the outputs of the 20-tone generators and serves to combine and amplify with a minimum of distortion. Side-band components of the generated PWS signal are limited to approximately 3,400 cycles in this unit. Preliminary tests have shown the composite signal output of the combining unit to be applicable to most standard telephone circuits.

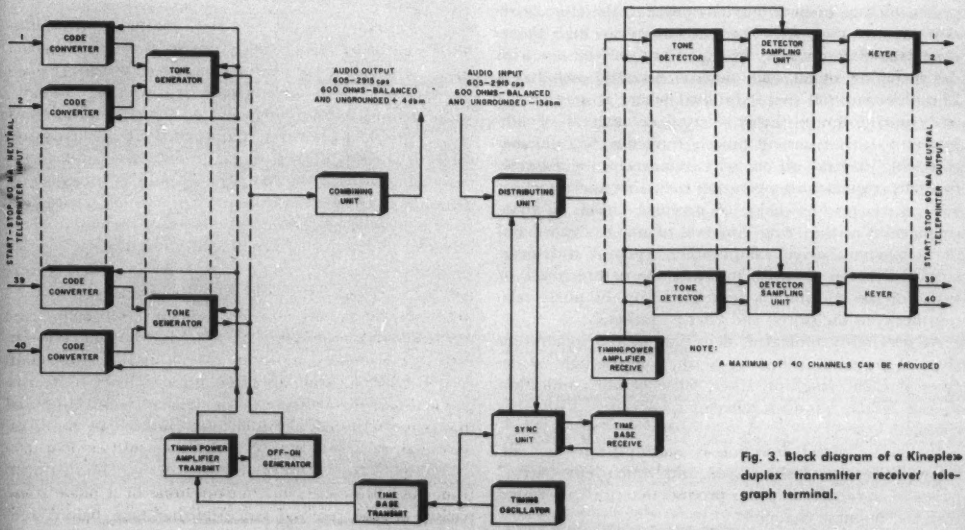


Fig. 3. Block diagram of a Kineplex duplex transmitter receiver telegraph terminal.

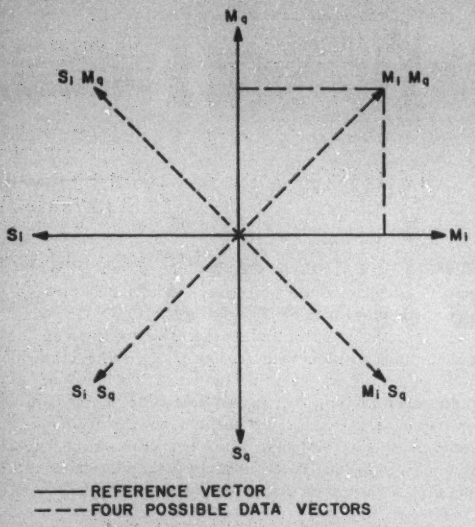


Fig. 4. Vector positions representing phase shifts between successive transmitted elements.

At the destination, as shown in Fig. 3, the incoming composite PWS signals are passed through a distributing unit, the principal function of which is to provide automatic control of the level applied to each of 20 PWS detectors.

DETECTION

THE OUTPUT from a PWS phase shift detector is defined as proportional to the scalar product of succeeding pulses. Storage of each previous pulse is, therefore, a requirement of the system. For each tone, two high Q mechanical resonators are turned on and off in step with the incoming signal such that, alternately, each has a 22-millisecond (60 speed) interval where it may "ring" or "coast" following every "drive" or interval of subjection to the incoming pulses. Immediately following this "ring" period, all energy is removed from the resonator by a quenching operation such that the resonator will possess no knowledge of previous pulses. A phase comparison of the "ring" interval of one resonator and the concurrent "drive" of the other results in a detector output, the sign of which indicates the nature (mark or space) of the information represented by the phase relation between the stored and "drive" pulses.

As previously indicated, detection of the quadrature channel is accomplished by a rotation through 90 degrees of each "ring" or stored pulse before applicaiton to the "scalar product detector" associated with that channel.

In-phase channel detection is accomplished by a direct application of the stored and concurrent "drive" pulses to an identical "scalar product detector" associated with the in-phase channel.

SAMPLING AND RECONSTRUCTION

RECONSTRUCTION of the synchronous binary pulses takes place in a unit designed to sample the detector output at a time when maximum signal energy has been transferred to a resonator. Accordingly, a positive or negative sample is taken from the detector output immediately following each "drive" interval. The detector sampling unit employs these positive or negative samples to operate a bistable oscillator, the output of which is the totally reconstructed signal. This signal is then passed to a "keyer," the function of which is to amplify for application to 60 milliampere teleprinting circuits. If high-speed data transmission is intended, shift registers may be employed at the output of the system ahead of the keyers. The keyers may be applied, as necessary, to provide output power levels suitable for specific load requirements.

TIMING

CHANNEL TRANSMISSION rates of 45, 55, and 75 bits per second are derived from basic timing frequencies of 727.3, 888.9, and 1,187.2 cycles per second, respectively, which

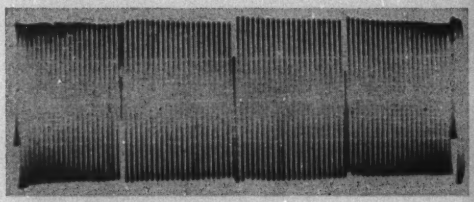


Fig. 5. Kineplex generator output of successive sine-wave elements.

are generated in timing oscillators located at the transmitter and receiver. Timing wave forms required by the code converters or shift registers, synchronizing equipment, detectors and detector sampling units are "locked" to the basic timing frequencies. At the transmitter, this is accomplished by direct frequency division; at the receiver it is accomplished by phase correction at the synchronizing unit as shown in Fig. 3 and is followed by direct receiver time–base frequency division. Phase correction, it will be recalled, is necessary to hold the receiver in step with the incoming PWS signals.

FREQUENCY STABILITY

FREQUENCY ERRORS resulting from instabilities in carrier service between Kineplex terminals may be as great as ± 10 cycles and may occur at rates as fast as one-half cycle per second when an automatic frequency control is employed at the receiver input. Output from the automatic frequency control is held to within one tenth of one cycle.

Frequency control information is derived by this unit from the 2,915 cycle synchronizing tone by a phase comparison of the received synchronizing tone before and

after passage through a highly stable mechanical filter.

PERFORMANCE IN NOISE

LABORATORY TESTS have indicated that for a one tenth of one per cent character error rate, a signal-to-noise ratio of —3 decibels in a 3 kc band is representative. This figure betters wide-band FSK performance by approximately eight decibels.[5,6]

Protection against impulse noise is expressly built-in in each detector. Limiting is automatically imposed on instantaneous noise bursts, the amplitudes of which are greater than 13 decibels above the composite signal level. Long-time increases in signal level cause no appreciable distortion due to limiting, since the threshold of limiting is held fixed for slow signal variations at a suitable margin above the signal.

PHYSICAL CHARACTERISTICS

THREE 86-½ INCH RACKS are required to contain one complete 40-channel duplex transmitter-receiver terminal. The total power requirement for such a terminal is approximately 1 kw; a total of over 2,000 transistors and approximately 65 mechanical resonators are employed. Figs. 6 and 7 are, respectively, photographs of a typical module and a typical mechanical resonator. Fig. 6 typifies the modular construction and printed circuitry.

SUMMARY

THE KINEPLEX SYSTEM has been characterized in this paper by the following: (a) high capacity, high bandwidth efficiency; (b) employable in the transmission of either business machine data or 60, 75 or 100 word-per-minute commercial telegraph; (c) minimum crosstalk between adjacent channels and between successive signal elements; (d) superior performance in the presence of noise; (e) transistorized printed circuitry and attendant reliability; (f) small in physical size and power requirement; and (g) direct applicability to commercial wire and carrier transmission services.

During October 1956, Kineplex evaluation tests were conducted over telephone wire and carrier circuits selected by the Bell Telephone Laboratories. A serial 450 bit-per-second system was tested over carrier and microwave facilities originating and terminating in the Burbank (Calif.) Laboratories of the Collins Radio Company, with relay points located at such distant locations as Santa Barbara and San Bernardino, both in California; Las Vegas, Nev.; and Denver, Colo.

A Kineplex system, involving four 60 word-per-minute channels with loading equivalent to 40 channels, has been under test for an extended period over a high-frequency radio path between Cedar Rapids, Iowa and Canoga Park, Calif., a distance of 1,800 miles. The results of these telephone and radio frequency tests have confirmed conclusions regarding Kineplex system characteristics relating to operation over both media.

Fig. 6. Typical Kineplex module and transistorized printed circuitry.

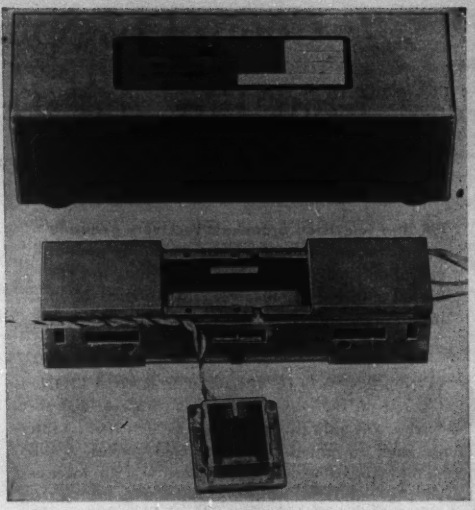


Fig. 7. Typical Collins mechanical resonator filter.

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Control of Spurious Radiation from FM and Television Receivers

R. J. FARBER

FM and television broadcast receivers generate significant amounts of r-f energy during normal operation. When these internal signals are radiated outside the receiver, interference often results. Some measurement and control history of such spurious radiation is described.

CONCERN WITH SPURIOUS RADIATION is based on the evident fact that in a crowded spectrum any allocations plan can be defeated by interference from unwanted and unexpected sources of radiation. Following World War II, there was an increased use of the radio spectrum for point-to-point services, navigational aids, television and FM broadcasting, etc., so that it is not surprising that trouble was encountered with spurious interference.

This interference can originate both in receivers and transmitters, as well as in a host of devices nominally not intended for or concerned with r-f communication. Interference from a receiver can arise from the local oscillator circuits, from direct radiation of high-level i-f or video-frequency components and their harmonics, and from high-level pulse generators such as the horizontal deflection circuits of a television receiver. Transmitters can radiate both harmonic and subharmonic signals in addition to their normal desired output. Finally, seemingly innocuous devices such as electric motors and gasoline engines can create a brand of havoc all their own.

APPROACH TO PROBLEM

CONSIDERATION of the over-all problem by the Federal Communications Commission (FCC) and by the Joint Technical Advisory Committee (JTAC) led to the realization that a blanket rule for the entire spectrum would be an unrealistic step due to the different requirements and limitations of the various users of the spectrum. The conclusion was reached that each general type of radio service should be considered separately and suitable regulations adopted. As an example of the need of this approach, some radio services have operated or attempted to operate in the past with quite low transmitter powers, requiring a very low interference level at the receivers; in such cases, the most desirable remedy is to increase transmitter power. This general approach of handling the interference problem by services is now being applied by the FCC.

The FCC, in addition, has differentiated among the various potential interference sources. It defines an "incidental radiation device" as "a device that radiates radio frequency energy during the course of its operation although the device is not intentionally designed to generate radio frequency energy." In distinction, a "restricted radiation device" is defined as "a device in which the generation of radio frequency energy is intentionally incorporated into the design and in which the radio frequency energy is conducted along wires or is radiated . . ." Transmitters and diathermy and related equipment are excluded from this definition.

Attention in the paper will be devoted to a particularly important class of restricted radiation devices, namely, FM and television broadcast receivers.

The problem of spurious radiation was thrown into sharp focus as soon as the television industry began to develop following World War II. Through ignorance rather than intent, the spurious radiation level from most early receivers was quite high. As a result, there were many instances of mutual interference between television receivers. For example, consider the situation of a receiver tuned to channel 7, having a picture carrier at 175.25 mc with a typical 26-mc i-f picture carrier. The local oscillator is tuned to 201.25 mc (175.25 + 26 mc). Since channel 11 extends from 198 to 204 mc, radiation from the channel 7 local oscillator could produce an objectionable beatnote on the picture tube of a receiver tuned to channel 11. Furthermore, the operation of standard AM broadcast receivers is interfered with by a strange set of whistles and noises that characterizes television receivers.

The problem of mutual interference among television receivers was bypassed by the adoption of the standard 45 mc intermediate frequency. On vhf channels at least, this step moved the local oscillator radiation to outside the television channels. On uhf it became the basis for the FCC allocation plan in such a way that potential local-oscillator interference in any particular area was minimized.

The various interested Government agencies were aware of the local-oscillator radiation problem, but the first case of direct governmental action came in the Spring of 1950. The CAA in running tests on VOR systems near Crawfordsville, Ind., had experienced interference from local-oscillator radiation from FM receivers. The situation was called to the attention of the various FM manufacturers, and subsequently in June of that year the Radio Manufacturers Association (now called Radio-Electronics-Television Manufacturers Association) FM Receivers Committee met with CAA representatives at

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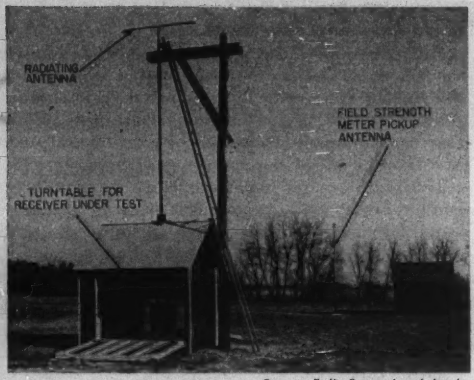
The author wishes to thank Dr. A. B. Glenn, chairman, and his colleagues on IRE subcommittee 27.3 for providing the basis for this article.



Courtesy Radio Corporation of America

Fig. 1. View of open field measurement range.

Indianapolis, Ind. An extensive series of tests was held to determine the effects of known levels of interference under actual operating conditions. The result of this experience was the conclusion by the committee that a radiation level of 50 μv per meter at 100 feet from an FM receiver is a desirable goal. Interestingly enough, this conclusion has withstood both time and theoretical analysis, and represents the present tolerable level of interference from 70 to 130 mc, which range includes both FM and low-band vhf television receivers.

METHODS OF MEASUREMENT

As soon as one begins to discuss field strengths of radiation from a receiver, the question of test procedures must be faced. After considerable theoretical and experimental work, IRE committees have devised standards for measurement of both radiated and conducted interference from FM and television receivers. It is worthwhile to review these procedures briefly.

The IRE Subcommittee (27.3) of the Radio Interference Committee is the group that concerns itself with, among other things, these standard methods of measurement of interference from broadcast and television receivers. (This group is the successor to the Radio Interference Subcommittee (17.4) of the Receivers Committee.) These groups have produced, to date, three standards which define methods of measurement of spurious radiation.

OPEN FIELD RADIATION

The earliest standard, *51 IRE 17.S1*, "Standards on Radio Receivers; Open Field Method of Measurement of Spurious Radiation from Frequency Modulation and Television Broadcast Receivers," describes the procedures for measuring open field radiation between 30 and 1,000 mc. In this measurement an attempt is made to simulate actual operating conditions. For example, the receiver under test is connected to a dipole antenna mounted 30 feet above the ground. This height is chosen as typical of the antenna height for an installation on a frame building. At a distance of 100 feet from the test receiver, the pickup antenna of the field-strength meter is located. This dipole is so mounted on a mast that it can be positioned at heights between 20 feet and 7 feet from the ground. The receiver under test, including its antenna, is rotated, and the search antenna lowered from 20 feet to 7 feet to locate the maximum field strength. Separate observations are made with the pickup antenna positioned horizontally and then vertically. Measurements also can be made of chassis radiation alone by replacing the antenna transmission line at the receiver with a 300 ohm resistor, and repeating the measurement procedure.

A general view of a typical open field radiation site is shown in Fig. 1. In the foreground, the shelter for the receiver under test can be seen. The front and rear walls of this enclosure can be lowered to determine whether they produce any significant modification of the radiated field. The antenna tower of the field strength meter is in the background. Notice that the shelter for the field strength meter and operator is located away from the pickup antenna to minimize the effect of extraneous objects in the field of the antenna, especially when it is near the lower extreme of its travel.

It is, of course, expected and hoped that any test procedure will lead to consistency of measurements. It is highly desirable that a given television receiver produce the same radiated field at any measurement site under all weather conditions. This condition does not entirely exist today, and measurements of the same receiver by different

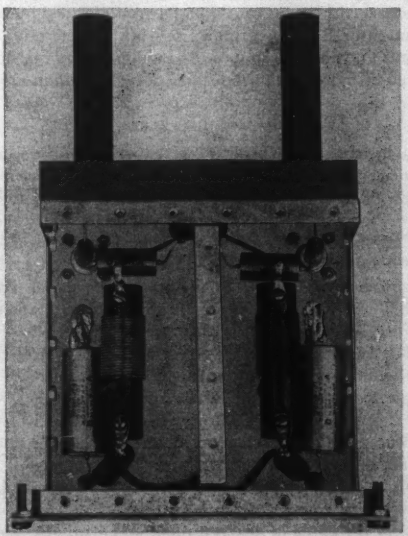


Fig. 2. Internal view of standard line impedance unit. Power-supply cord enters at the bottom, and outlet for the receiver is at the top.

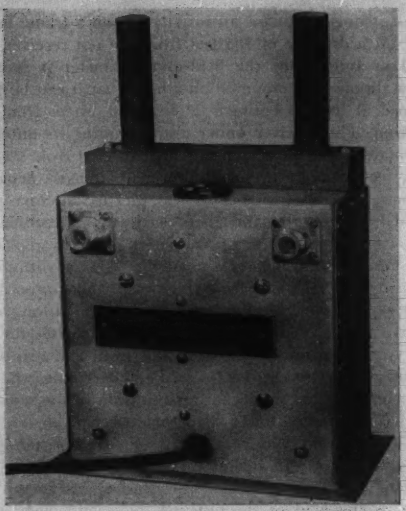


Fig. 3. Standard line impedance unit. Connections to the measuring equipment are made at the two type *N* coaxial connectors at the upper corners.

laboratories in one series of tests, for example, have indicated ±3 db variation at vhf and ±6 db variation at uhf. As a result of such co-ordinated tests, as well as independent work by the various laboratories involved, a good deal of knowledge has been accumulated concerning this measurement procedure. A special group headed by E. O. Johnson of RCA is currently at work to determine the extent to which the supposedly random errors can be reduced by more precise and sophisticated techniques.

CONDUCTED INTERFERENCE

FOR FREQUENCIES BELOW 25 MC, experience has revealed that open field measurements are inferior to direct measurements of the interfering voltage produced by the receiver between its power supply terminals and ground. For television receivers, this interference can be produced by the horizontal deflection circuits, by high-level video components, and by the 4.5-mc intercarrier-sound signal. In FM receivers, the 10.7-mc i-f signal and its harmonics can usually be detected.

IRE Standard *54 IRE 17.S1*, "Standards on Receivers: Methods of Measurement of Interference Output of Television Receivers in the Range of 300 to 10,000 Kc," and supplement *56 IRE 27.S1* "Standards on Methods of Measurement of the Conducted Interference Output of Broadcast and Television Receivers in the Range of 300 Kc to 25 Mc," describe the methods by which these measurements are to be made. According to the procedure, the receiver is located in a screen room and a suitable signal delivered to its input. The power line is given a 50 ohm impedance from each side to ground by means of a standard power-line stabilization filter. The voltage developed across the 50 ohms is taken as an indication of the magnitude of the interference components.

This network is an example of the methods used in the standards in an attempt to obtain consistency of results. The standard specifies the input impedance characteristic within ±5%, and suggests an internal mechanical layout. There are even specified a pair of posts around which the excess power cord of the receiver is wrapped. Internal and external views of a standard line impedance unit are shown in Figs. 2 and 3. As a result of such care, measurements of conducted interference in the broadcast band made on the same test television receiver at eight different laboratories showed a variation of less than ±1.5 db. At higher frequencies, somewhat greater spreads were experienced, and the factors causing these inconsistencies are currently under study.

The work of the various industry committees and governmental agencies in this field reached a climax in December 1955 when the first sections of the new Part 15 of the FCC rules were issued. In these new rules, maximum allowable radiation levels are prescribed, and it is required that receivers be certificated to the effect that they comply with these limits. Specifically, the limits involved for radio receivers operating between 30 and 890 mc are:

Frequency of Radiation in Megacycles	Maximum μv per meter at 100 feet
Over 25 up to and including 70	32
Over 70 up to and including 130	50
130-174	50-150 (linear interpolation)
174-260	150
260-470	150-500 (linear interpolation)
470-1,000	500

Between 450 kc and 25 mc, the conducted-interference limit is 100 μv between either side of the power line and ground. In all cases, measurements are to be made in accordance with the two standards outlined above.

After these years of study and field tests (as well as considerable interference from FM and television receivers), actions have now been taken which, it is hoped, will confine the unwanted signals from FM broadcast and television receivers so that they will cease being a source of interference to themselves and to other radio services.

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Driving Point and Transfer Impedance Computation

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THERE ARE a number of power system problems in which the driving point and transfer impedances of the network are required. In the past, the network analyzer has been widely used to determine these impedances by measurement; however, there is a serious question as to whether the accuracy obtainable with analyzer measurements is sufficient for all purposes. An example where analyzer accuracy is questionable is in the determination of open-circuit impedances, sometimes referred to as self and mutual impedances, for use in loss equations. Several methods of computing such impedances digitally have been described.[1]

The network of Fig. 1 is used to define the problem under consideration and to illustrate the method of attack. The basic problem is that of determining the open-circuit driving point and transfer impedances of the network from a knowledge of the branch impedances, the turns ratios of the ideal autotransformers, and the geometry of the network.

As the first step, the autotransformers are removed from the network, leaving the branches representing the impedances of lines, line charging capacitors, and transformers. The result of this step is indicated in Fig. 2 by means of a network graph showing the resulting collection of nodes and branches.

The driving point and transfer impedances of the network of Fig. 2 are now computed. To accomplish this, a tree of the network is specified, containing a sufficient number of selected branches so that all nodes are connected in such a manner that there are no closed loops. There are several possibilities for trees. The one used consists of branches 1 through 7. Since there are no closed loops in the tree, its driving point and transfer impedances can readily be established. The links of the network, the branches remaining after the tree is selected, are inserted one by one. As the first link is connected, a closed loop is formed. For example, the connection of branch 8 produces a closed loop consisting of branches 8, 1, and 3. The loop current is eliminated from the network equations before proceeding. The next link is then connected, with the resulting loop being eliminated immediately. When all links have been connected and loop currents eliminated, the result is the driving point and transfer impedances of the network less the autotransformers.

As the final step, the autotransformers are connected one by one. As each autotransformer is put in place, a closed loop is formed and is eliminated before proceeding. When all autotransformers are in place and the final closed loop has been eliminated, the result gives the desired impedances.

The method described has the following features:

1. The network geometry is defined in terms of a tree and links. This ensures the independence of the network equations and provides a convenient way of organizing the data.

2. The repetitive nature of the routine is well suited for programming for digital computers.

3. Branch impedances and turns ratios can be changed without the necessity of starting the computation routine anew.

4. The line charging capacitance is properly included as a part of the network and the neutral connection of line charging capacitors and autotransformers is retained as a separate node.

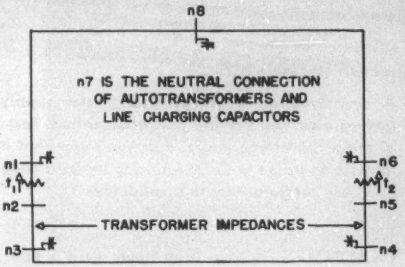

Fig. 1. System diagram.

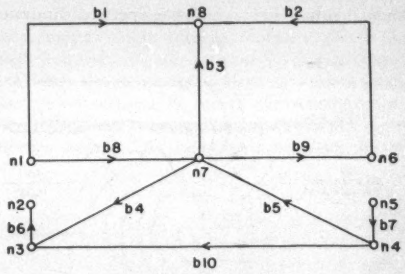

Fig. 2. The network diagram.

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A Wind-Operated Electric Power Supply

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A new type of wind-operated power supply having only one moving part is described. Tests of more than three years' duration show that it may be operated without servicing under a wide range of weather conditions.

EXPERIMENTS have been made with a new type of wind-operated electric power supply which shows considerable promise. A small prototype model was built, having an effective wind cross-section of about 1 square foot, which has operated continuously for three years under normal weather conditions, including rain, snow, moderate icing, and occasional high winds. During this period, it has had no servicing and has presented no operating difficulties whatever. This generator has an average output of 1 watt with winds averaging around 11 miles per hour, increasing about as the cube of the velocity.

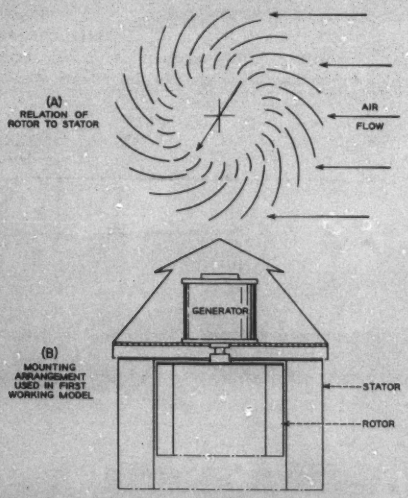

Fig. 1. Sectional view of wind-operated power supply test model.

Apart from the ability to capture useful amounts of energy, one of the chief attributes is the ability to operate unattended for long periods of time. This is an important consideration, especially in small installations where the reduction in maintenance may be a controlling factor. Attention was given to reducing the number of wearing parts and moving electric contacts to the minimum in a structure designed to operate through very adverse weather conditions. The result is a system with a single rotating member and with no moving electric contacts.

A turbine type of wind rotor is used which is mounted on a vertical shaft rotating within a set of stationary deflecting blades as shown in the horizontal sectional scale drawing, Fig. 1 (A). Wind blowing from any direction is captured by the stationary blades on the windward side. The air velocity is substantially increased by the funneling action of the stator blades; it then imparts momentum to the rotor blades on the entering side, causing counterclockwise rotation. The air, still with increased velocity, sweeps across the interior of the rotor with changed direction and again imparts momentum, in the same rotation sense, to the rotor blades on the exit side. The air then leaves the rotor at reduced velocity and is carried away with the general flow behind the structure.

The sectional drawing, Fig. 1 (B), shows the vertical arrangement of parts. The rotor is mounted on the shaft of a permanent-magnet generator which is provided with oversized ball bearings lubricated for long operation. The generator is mounted within a weatherproof housing which protects it from water, ice, and snow. The wind rotor and the system of stationary blades are constructed so that they are entirely open underneath in order to allow drifting snow to fall through freely. The rotor and the stationary blade and generator assembly are shown in Figs. 2 and 3.

Inasmuch as all directions are equally favorable, the rotor receives energy continuously from the wind through the most gusty conditions, even including large, rapid changes in direction. No auxiliary gear is required to adjust for wind direction, resulting in a substantial saving in mechanical parts and their maintenance. Much of the horizontal thrust is absorbed by the stationary blades with a corresponding reduction of forces on the rotating system.

The rotor of the new wind generator turns at relatively low speeds, having a peripheral velocity in the order of half that of the wind. This is an advantage from the standpoint of long bearing life.

The arrangement and curvature of the rotor and stator blades were determined empirically and were

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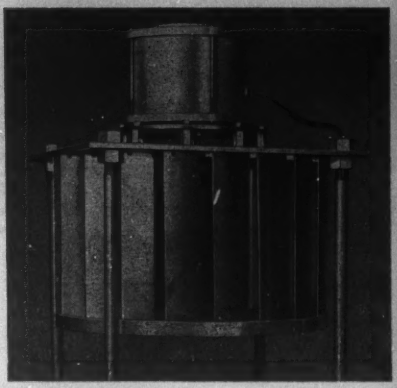


Fig. 2 (left). Photograph of rotor. Fig. 3 (right). Assembly of stator-blade structure and electric generator without weatherproof housing.

chosen primarily because in trials they gave the most power at low wind velocities. All of the curves used are circular arcs, and, where the stator blades are adjacent to the rotor blades, they are tangent. In the present model, there are 24 blades on the rotor and 20 on the stator, the different numbers being chosen to reduce the siren effect. With the blade structure used, the wind speed through the rotor is increased approximately in a ratio of 8 to 7.

The electric generator, especially designed and supplied by the Holtzer-Cabot Division, National Pneumatic Company, Inc., for this project, is of the multipole rotating-magnet wound-stator type and generates an alternating current having a frequency 30 times the rotation speed without the use of slip rings or any other moving contact. As used in all tests to date, the alternating output is converted to direct current by means of silicon diode rectifiers connected to a constant load, with a storage battery in parallel to absorb excess energy during periods of high wind and to provide continuity during periods of calm.

The electrical load circuit used in the present tests is shown in Fig. 4, and some characteristics of its operation are illustrated in Fig. 5.

The generator produces an alternating current with open-circuit voltage and frequency about proportional to the wind speed. A tuned circuit, comprising a capacitor C and inductor L, resonates the generator output, and a rectifier connected across the inductor converts the alternating output to direct current when the rectified voltage exceeds that of the storage battery. The battery is connected continuously to a suitable load, which might be, for example, a transistor amplifier. The purpose of the tuned circuit is to make effective use of the wind over a wide range of speeds without the use of auxiliary windings or other automatic controls.

The tuned circuit is designed to be resonant at the frequency corresponding to the lowest wind speed worth considering. As the speed increases toward this value, the voltage across the inductor builds up to the amount which will just cause some d-c power to be delivered from the rectifier. A further increase in speed results in more delivered power and a load resistance across the inductor. The effective inductance is reduced thereby, and the tuning changes correspondingly to match the increased frequency of the generator. This process continues until the generator voltage is high enough to deliver power without benefit of the tuned circuit. At higher speeds, the tuned circuit automatically becomes ineffective because the capacitor impedance decreases,

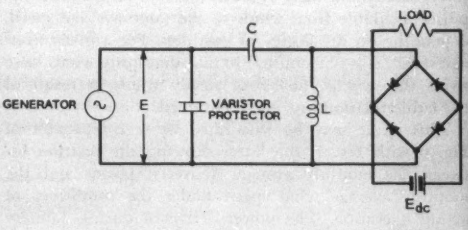


Fig. 4. Load circuit used in tests of wind-operated power supply.

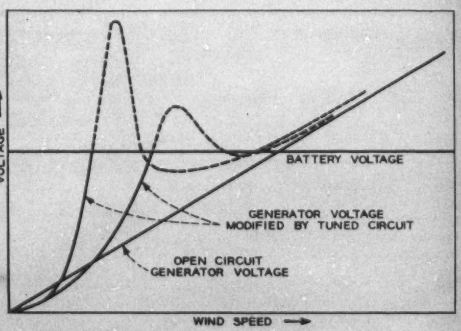
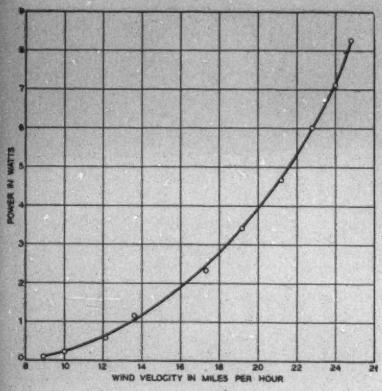


Fig. 5. Operation of battery-charging circuit.



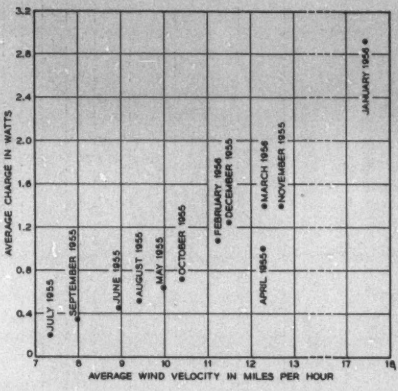


Fig. 6 (left). Power vs wind speed for steady winds. Fig. 7 (right). Average power vs average wind speed for variable winds.

while that of the industor increases with increased frequency.

The relation between generated power and steady wind speed is shown in Fig. 6. The correspondence is very nearly cubic, the deviations chiefly being the result of variations in the efficiency of the electric generator with speed and of changes in the relative effect of frictional losses, especially in the low power range.

The information in this form is inconvenient to use for making extrapolations, because the wind speed is rarely steady and there is a considerable variation in the power available from winds of the same average speed, depending on the degree of gustiness. For a given average speed, it is not unusual to find that gusty winds have twice the average power of steady winds, a result of the cubic relationship just mentioned.

This effect may be illustrated by a comparison of Fig. 6 with Fig. 7, the latter showing the relation between the monthly average delivered power and the monthly average wind speed under the conditions of actual operation. The power delivered during January 1956 was smaller than would be expected because a silicon carbide protector is connected across the generator to provide protection against excessively high generator speeds during periods of high wind speeds. During January much of the potential power was contained in winds of such high speed that the protector was operating a larger proportion of time than during the other months. It is believed that adequate protection can be obtained with less loss of useful power.

Table I. Analysis of One Year's Operation of Small Test Generator

Month	Average Wind Speed, Miles per Hour	Average D-C Power, Watts	Efficiency, Per Cent
April 1955	12.18	0.99	8.5
May	9.87	0.65	8.7
June	8.80	0.41	8.3
July	7.34	0.20	7.3
August	9.37	0.51	6.1
September	7.97	0.36	6.4
October	10.40	0.72	7.6
November	12.74	1.39	6.8
December	11.47	1.25	7.4
January 1956	17.30	2.95	6.6
February	11.23	1.04	7.2
March	12.45	1.40	7.9
Average for year	10.95	0.99	7.4

The performance of the new wind generator over one years' operation is summarized in Table I. The efficiencies shown are the ratio of delivered d-c power to the total power in the wind computed from the measured wind speeds.

The purpose of the current experiment in wind power is primarily to study the mechanical advantages of the new type of structure and to obtain some idea of its conversion efficiency. In the present location, the wind speeds are so low during much of the time that little or no power is developed. However, there is a wide variation in the speed, and it has been possible to obtain a correlation between speed anad power over a considerable range. For example, at 20 miles per hour, an output of 4 watts per square foot is generated, with an efficiency of a little over 11 per cent. At this speed, the efficiency of the electric generator used is about 50 per cent. In a larger machine, because of the more efficient electric generator possible, and the lower proportional frictional losses, an efficiency in excess of 20 per cent could reasonably be expected. The power that would be obtained from wind generators of various sizes, assuming an efficiency of 20 per cent, is indicated in Fig. 8 as a function of wind velocity.

It is unlikely that it would be desirable to construct wind-power units of large capacity simply as scaled-up versions of the small model described. A preferred mechanical construction would be somewhat as illustrated in Fig. 9, which would permit access to the generator for occasional servicing and reduce the required rigidity of the supporting structure.

A variety of electric generator types could be used, depending upon each specific application. In larger machines, it probably would be desirable to use special

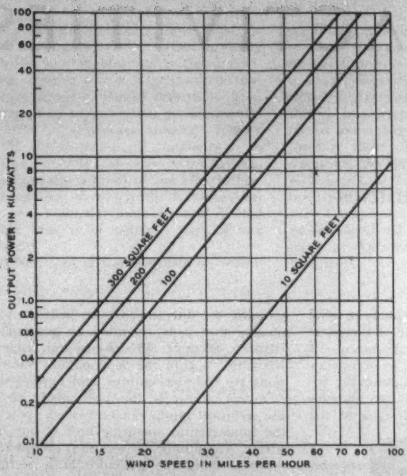


Fig. 8. Power available from wind generators of various cross-sections, computed at 20-per-cent efficiency.

compound winding in order to obtain a good impedance match to the load for a wide range of wind speeds, rather than any arrangement of tuned circuits such as used in the small prototype model.

An interesting possibility for delivering power from the wind into existing a-c networks would be to connect induction generators in parallel with the transmission lines so that power with leading power factor would be produced whenever the wind speed is above some critical value. Automatic cutouts could be used to disconnect the generators whenever the wind speed drops below this value.

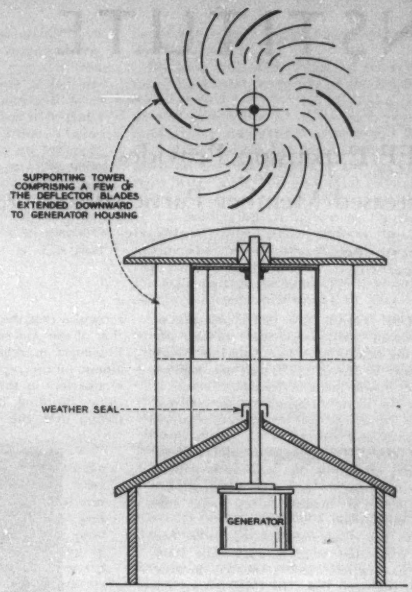

SUPPORTING TOWER, COMPRISING A FEW OF THE DEFLECTOR BLADES EXTENDED DOWNWARD TO GENERATOR HOUSING
WEATHER SEAL
GENERATOR

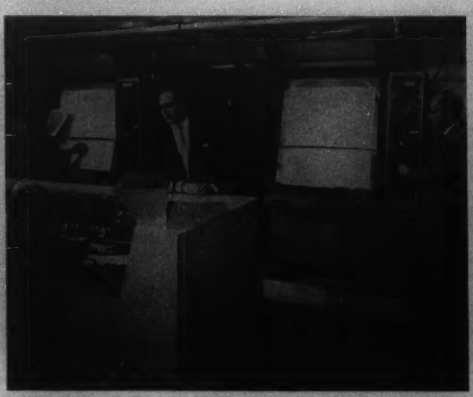
Fig. 9. General layout for proposed medium-scale wind-power generating plant.

It is well known that large amounts of power are available from the wind and that the successful use of it depends upon the design of equipment that can capture it and convert it into useful forms economically. The new type of windmill herein described is proposed as one possible solution to that problem.

Radio Center for Electronic Flight

Radio communications and navigation facilities for five electronic flight simulators at the Denver, Colo., flight training center of United Air Lines have been consolidated into a radio control center with resultant gains in efficiency.

Communications and navigation aids normally are integral units of each flight simulator. United has removed these units from the Curtiss-Wright Dehmel simulators and placed them in a centralized radio control room. Only three sets of communications and navigation units are required, in contrast with the five which otherwise would be needed. Additional advantages are more effective use of radio aids operating personnel, greater flexibility, greater realism in training by removal of the radio aids operator and equipment from proximity to the simulator cockpit, and improved economy and higher utilization of radio equipment.



INSTITUTE ACTIVITIES

AIEE Expansion Provides Increased Member Participation Opportunities

M. S. COOVER
PRESIDENT, AIEE

SUPPOSE THAT AN ISSUE of one of the Jackson daily newspapers carried the following news item: "The American Blank Company is one of the fastest growing industries in the Jackson, Mississippi, area. It is now the world's largest firm devoted exclusively to design and production of precision items and accessories for specific purposes. Mr. X, vice-president and general manager, attributes the impressive growth of his company to research, advanced design, precision manufacturing, and customer satisfaction.

"Sales this year are expected to be five times what they were in 1920. The company has experienced a steady, healthy growth over the years. In 1948, it outgrew its Jackson location and moved some of its operations to suburban Jackson. Even now continuing expansion is taxing present quarters and the company is contemplating new and larger facilities. For some time, the company has been operating principally through five divisions supplying its products to its customers directly from these five divisions. Expanding technological developments, the necessity for reaching a newly created market, and the desire to explore that market prompted management to decide last year to add a sixth division; also to compartmentalize its operation within five distinct areas of management. Further changes in the structure of its management presently are under contemplation."

And as you read further you discover that, "the company was founded in 1884 by a group of farsighted engineers who saw a need for precision products. Within the first year the company practically trebled in size thus justifying for the time being the judgment of its founders. The affairs of the company have been handed down through the years to men who have maintained an upward slope to the company's growth curve except for some three years during the middle 1930's when the majority of business enterprises were having the same experience. The company looks forward confidently to being able to maintain a continuing steady growth with quality service to its customers."

I doubt very much if this is the exact story of any particular business firm in Jackson, but surely by now many of you recognize that the story does closely parallel that of the American Institute of Electrical Engineers in relation to its founding, its almost uninterrupted growth, its occupancy of quarters in the present Engineering Societies Building, its administrative reorganization over the years as adjusted to the remarkable progress that has taken place in the electrical field, and its current deliberations regarding both the present and future of the Institute.

M. S. Coover

Service to the Individual

The Institute is a service organization. It is operated for that purpose. It can be a vitally important factor in the personal and professional development of its members. If the AIEE is to render effective service to its members the activities of the Institute somehow must be shaped so that the individual member can participate effectively and benefit thereby. The character and quality of services that are available through the Institute must be such that the individual member will see that he is the one who is in a position to gain, especially if he is eager for new ideas and to learn of new products and processes, not to overlook the tremendous values in human relations that accompany the interchange of ideas and information on subjects that are of mutual concern.

The Institute exerts every known effective method to take itself out to its members. That is one reason for the District Meeting here in Jackson this week. That is the reason for holding several district meetings and three general meetings each year. That is the reason for holding all of the other types of meetings with which you are familiar. One of the primary objectives is the free exchange of knowledge. As you visualize the operation of the Institute you observe that it is organized by geographic Districts, Sections, Subsections, and Student Branches. Within the Sections and Subsections are technical groups, and beyond the technical group is the individual, hence the technical group can be looked upon as the fundamental operating unit of our Institute. Any number of technical groups can operate under the guidance of a Section or Subsection. The number of individuals with common subject-matter interest who may comprise a technical group can be from two on up and without limit. Where a technical group emerges, there soon develops a natural desire to effect some kind of organization to advance the purposes that they have in common and to facilitate the interchange of information. Here is one of the most important areas of opportunity and responsibility for Institute officers and technical committee chairmen.

The opportunities and the responsibilities for having the Institute reach the individual member are not centered at any one location, or with any individual, or for that matter with any one component of Institute organization. Proper assessment will reveal that the Institute would be meaningless, in fact nonexistent, were it not for what we as individuals put into it. Members may participate in one way or another at any level either as individuals or through committee activities. There must be mutual dependence and a co-operative effort. There must be the kind of teamwork that every member on the team enjoys. We need each other. The simple truth is that neither we ourselves, nor our "employer," nor his "business" can survive and prosper unless and until we as individuals can reflect our skills in high-quality output whether in products or services.

Judging from the current volume and the nature of advertisements, also the intensity of recruiting at our educational institutions, there is a continuing widespread recognition of need for a greater number of technologists to bring scientific discoveries more quickly into applications to meet the pressure for expansion of industry and requirements of the military. The situation is not new to any of us nor does it seem that the stress of circumstances will slacken within the foreseeable future.

Identification with AIEE

As the engineer participates in this huge parade of progress he finds himself in a society based largely upon group relations. This realization should and probably does

Essentially full text of a speech delivered at the AIEE Southern District Meeting, Jackson, Mississippi, April 3-5, 1957.

M. S. Coover is the administrative assistant in the Division of Engineering of Iowa State College, Ames, Iowa.

make him professionally conscious. It should and probably does create a desire to identify himself with the national engineering organization or organizations that can most effectively make returns to him. Speaking to an audience that predominantly is electrical engineering minded, I note that the pre-eminence of contributions to literature in electrical engineering by authors of papers is proof of the effectiveness of the manner in which our technical sessions are conducted and of some of the tangible benefits of being a part of our Institute.

The functions of our Institute lie within the total area of electrical engineering in all of its well-established and recognized segments. I believe that every engineer who is identified with one or more of our national engineering organizations will agree that in some measure those ties have really meant something to him, and that in some measure those ties have had an influence upon his personal development. My conviction is that boundless opportunities are open to every member of our Institute, and may I emphasize that an enthusiastic, dynamic membership can mean an ever expanding American Institute of Electrical Engineers.

Montreal Will Be Scene of 1957 Summer General Meeting

MONTREAL, the Metropolis of Canada, will be the scene of this year's AIEE Summer General Meeting, June 24-28, 1957. Meetings will be held in the Sheraton-Mount Royal Hotel.

Hotel Reservations

This is a reminder to those who have not yet made their reservations with The Montreal Tourist and Convention Bureau, the lodging agent for this meeting. It will be difficult, if not impossible, to obtain hotel accommodation if reservations are not received by May 24, 1957. Reservations should not be sent to the hotel. They must be sent to: The Montreal Tourist and Convention Bureau, Suite M.30, 1455 Peel St., Montreal 2, Que., Canada.

Hospitality

An informal tea, organized by the Hospitality Committee, will permit those attending to meet their friends and make new acquaintances. If you are in Montreal, make sure not to miss this informal gathering in Salon C.-D.-E. of the Sheraton-Mount Royal on Sunday afternoon, from 3 to 5 p.m.

Monday through Friday, during the Meeting, a buffet-luncheon will be served in the Champlain Room of the Sheraton-Mount Royal. Monday's luncheon will feature a guest speaker.

Smoker

Plan to renew old friendships and make new friends at the Smoker to be held at the Sheraton-Mount Royal on Tuesday evening, June 25, 1957. Good food in the form of a cross-Canada buffet offering dishes from the Maritimes to the Prairies, good fellowship, and a top variety show will be the features of this highlight event of the Summer General Meeting.

Write for tickets now; accommodations are limited. Price: $12 per ticket. Requests for tickets should be addressed to: Entertainment Committee, c/o R. C. Short, Room 320, 159 Craig Street West, Montreal, Que., Canada.

All requests should be accompanied by checks made payable in Canadian Funds obtainable through one's local bank, to AIEE Summer General Meeting.

Golf Tournaments

Delegates are invited to take part in the golf tournaments played on Tuesday, June 25, and Wednesday, June 26. Montreal and its surrounding area offer tremendous golf facilities. Why not try for the Lee trophy?

June 25 will be used as a qualifying 18 holes to limit the number of contestants of the June 26 tournament. Arrangements will be made also to permit delegates and their wives to play at other courses. Club privileges will be obtained for those delegates who would like to play tennis.

President's Reception

Thursday, June 27, features one of the most important events of the Meeting: the President's Reception, followed by a dinner-dance listed as informal. Orchestration has been prepared for: square dancing, polkas, Virginia reels, fox trot, waltzes, cha-cha, etc.

Inspection Trips

A program of nine inspection trips has been arranged to allow delegates to become familiar with the engineering work being done in Canada.

On June 25, a TCA chartered plane will take 44 delegates to the site of the Bersimis Power Project for a full day inspection tour of the unique mountain-enclosed powerhouse, the gravity-type Desroches and Bersimis dams, the gigantic surge tank, etc. Located on the North Shore of the St. Lawrence River some 340 miles from Montreal, this development has an ultimate capacity of 1.2 million hp. It is one of the most important hydroelectric projects in the world. The over-all time required for the trip will be approximately 15 hours, and the main part of the journey will be made aboard a turboprop Viscount air liner.

Tickets are limited to 44 persons and are priced at $50, including all expenses. Application for reservations, accompanied by a check or money order for the aforementioned amount in Canadian funds, obtainable at a local bank, may be addressed to: Mr. R. E. Grout, AIEE Summer General Meeting—1957, Chairman, Committee for Inspection Trips, c/o The Shawinigan Engineering Co. Ltd., P. O. Box 6072, Montreal, Que., Canada.

Also on June 25, two other trips are planned—one in the morning and one in the afternoon. The morning trip will be a tour of Hydro-Quebec's Service Center to see the microwave equipment that links Montreal, Charlesbourg, and Bersimis. The afternoon trip will be a visit to Lachine, a suburb of Monteral, to see a hydroelectric turbine and pump manufacture and also the test laboratory.

One June 26, a morning trip to Montreal Locomotive Plant will be held. The emphasis will be on diesel electric locomotive production. Also on June 26, there will be an afternoon trip to the St. Lawrence Seaway, to see the work in the Lachine Section extending to Beauharnois.

Another inspection trip on June 26 will be to Beauharnois, some 20 miles from Montreal to visit the Beauharnois Power Development, the main source of electricity for the Metropolis. This visit also will include an inspection of the third and final

MEMBERS taking the Summer General Meeting inspection trip to the site of the Bersimis Power Project will view the control room of the Bersimis I Generating Station, nerve center of the plant.

Photo by Armour Landry

THE ELECTRIC METER testing shop at Hydro-Quebec's Service Center (above, *left*) in Montreal, Que., Canada, will be visited during one of the Summer General Meeting inspection trips. Above, right: General view of the fourteen 55,000-horsepower turbines of Section No. 2 at Hydro-Quebec's Beauharnois power plant. A trip to Beauharnois will take place on June 26.

section of the powerhouse now under construction. Once completed, this third section will increase Beauharnois' production to 2.16 million hp.

On June 27, 75 delegates will have the opportunity to visit the Quebec Iron and Titanium Smelter Plant and the Shawinigan Water and Power Company's 230 kv Terminal Station at St. Joseph de Sorel.

On June 27, another inspection trip to Lachine has been organized to visit Northern Electric's Wire and Cable Plant, where the process of manufacturing communication cables will be illustrated.

On June 28, a tour of inspection of a few of Hydro-Quebec's substations in the Montreal area, including the new 300 kv Terminal Station at Bout de l'Ile where some of the largest transformers in the world have been installed. The Bout de l'Ile Station is the terminal of Bersimis-generated power.

Ladies Entertainment

The Ladies Entertainment Committee is arranging a series of special events for the 1957 Summer General Meeting. Tuesday, June 25, there will be a special event at the famous Bellevue Casino. Wednesday, June 26, the ladies will have a chance to visit the Laurentian Mountain resorts by bus; a lunch will be served at the Chanteclair. On Thursday, June 27, a sight-seeing tour around Montreal will be held. On that occasion the City of Montreal will play host to the ladies and serve tea on historic St. Helen's Island.

Summer General Meeting Committee

Members of the 1957 Summer General Meeting Committee are: F. L. Lawton, chairman; W. R. Wray, vice-chairman; C. L. Roach, secretary; D. M. Farnham, treasurer; F. L. French, technical program co-ordinator; H. W. Haberl, entertainment co-ordinator; C. A. Wright, services co-ordinator; A. C. Abbott, Montreal Section representative. The Committee Chairmen are: W. R. Wray, finance; C. E. Wollgar, registration; T. F. Palmquist, meetings and papers; J. Lawrence, W. Schippel, students; H. W. Haberl, smoker; P. W. Howlett, hospitality; Mr. and Mrs. H. H. Remine, ladies; R. C. Short, sport; J. M. Sharpe, social; O. Francoeur, hotels and rooms; Leo Roy, publicity; W. R. Simons, information; J. D. Sylvester, transportation.

Thousands Gather in Philadelphia, Pa. for 1957 Nuclear Congress, Held March 11-15

THE ROLE of the United States in bringing nuclear energy to power-starved nations of the world was outlined to thousands of engineers, scientists, and business executives in Philadelphia, Pa., as part of the largest meeting on atomic energy ever held in this country. The 1957 Nuclear Congress, held March 11-15, at Philadelphia's Convention Hall, was an assembly of three important conferences—the 2nd Nuclear Engineering and Science Conference, the 5th Atomic Energy in Industry Conference, the 5th Hot Laboratories and Equipment Conference—and the 3rd International Atomic Exposition. The Congress was sponsored and conducted by 24 leading engineering and scientific societies and co-ordinated by the Engineers Joint Council (EJC).

On Sunday, March 10, a special Students' Day program was presented to 2,500 invited students and teachers of mathematics and science, in order to assist in explaining this new science so that those best qualified might be encouraged to investigate this area as a field to follow. Features of the program included an address by Robert McKinney, chairman, U. S. Panel on Peacetime Uses of Atomic Energy; a demonstration entitled "Atomic Energy: Weapon for Peace" by Dr. H. N. Alyea, professor of chemical engineering at Princeton University; and a special preview of the Exposition.

A highlight of the Congress was the All-Congress Banquet, held March 13 at the Bellevue-Stratford Hotel. The toastmaster, W. G. Whitman, head of the department of chemical engineering, Massachusetts Institute of Technology, introduced the principal speaker, P. F. Foster, vice-admiral, USNR (Ret.), assistant manager for international activities, U.S. Atomic Energy Commission, whose subject was "The International Outlook for Atomic Power." In presenting a brief survey of this country's nuclear construction during the past year, he stated that the atomic energy industry in 1956 began construction or received contracts on 59 new nuclear reactors, including 30 research and test reactors. The research and test reactors will be built for private U. S. buyers, for the Government, and for export. The 29 power reactors are for naval and merchant ship propulsion and for land-based power demonstration plants for private purchasers.

Alfred Iddles, president of Babcock & Wilcox Company, and president of the Atomic Industrial Forum, Inc., presented "A Message from EURATOM," a progress report from the European atomic energy community representing six European countries—Belgium, France, Western Germany, Italy, Luxembourg, and The Netherlands. This commission has the responsibility for supplying the six countries with nuclear fuel of all kinds, ores, and special fissile (fissionable) materials. It will be the sole agency with the power to acquire the nuclear fuels produced on the soil of the member countries and to conclude agreements of supply with 'third countries'."

Of special interest to AIEE members was the AIEE Dinner and Technical Session sponsored by the Philadelphia Section and held Monday evening, March 11. The feature was a paper "The PAR Homogeneous Reactor Projects—Plant Design and Operating Problems" by W. E. Johnson and D. H.

Fax of the Westinghouse Electric Corporation, and S. C. Townsend of the Pennsylvania Power & Light Company. The paper, presented by Mr. Townsend, describes the PAR (Pennsylvania Advanced Reactor) project near Pittsburgh, Pa., a large aqueous homogeneous reactor jointly financed by Westinghouse and Pennsylvania Power & Light Company. The chief problem is that of remote maintenance, necessary in a project of this type. An interesting consideration is the relative insignificance of the raw fuel cost for the project, estimated at only $4,000 a year for the 150-mw reactor.

Another interesting address was one presented at a dinner sponsored by the American Society of Mechanical Engineers, entitled "Is American Atomic Policy Lagging?" The speaker, R. M. McKinney, editor of the *Santa Fe New Mexican* and chairman of the Panel on Peaceful Uses of Atomic Energy, discussed atomic energy growth in Europe and the role of the United States in contributing to this growth. Although a great deal is being accomplished, he believes there are many areas in which our program is lagging. He concluded by stating that "it is the lack of constructive national atomic policy, the failure to carry out enthusiastically such policies as we have, which now prevent the civilian uses of atomic energy from being an effective instrument for peace."

Technical Sessions

More than 200 papers were presented during the week at the various technical sessions. The 15 AIEE-sponsored papers were as follows:

"Some Operational Problems of the Nuclear Power Plant" by R. L. Witzke and A. R. Jones of Westinghouse Electric Corporation, Pittsburgh, Pa., which examines in some detail the problems of nuclear plant operation. Among the areas covered are startup, normal operation, normal and emergency shutdown, maintenance, refueling, and manpower.

"Health Physics Instrumentation for a Power Reactor" by G. H. Whipple, University of Rochester Atomic Energy Project, Rochester, N. Y. In this paper, reactor instrumentation is suggested based upon the measurements required, the necessary ranges and accuracies, and the classes of instruments and their application.

"Safety Circuit Development at Brookhaven National Laboratory" by J. E. Binns, W. Lones, and D. G. Pitcher of Brookhaven, and M. Melice of the Nuclear Development Corporation of America, was a discussion of some of the underlying principles in the design of neutron-sensitive safety circuits for the protection of nuclear reactors and a description of a safety system based on these principles.

"Recent Developments in Nuclear Instrumentation at the Knolls Atomic Power Laboratory" by R. S. Stone of the General Electric Company, covered typical instrumentation, reactor monitoring, and protective instrument systems, as well as auxiliary instruments for neutron physics experiments.

A paper by M. Koblentz, R. M. Spiegel, S. Kass, and H. Sterling of Fischer & Porter Company, Hatboro, Pa., entitled "Ultrasonic Flowmeter Monitors Reactor Heat Exchange Circulation," gave a description

Future AIEE Meetings

North Eastern District Meeting*
Wendell-Sherwood Hotel,
Pittsfield, Mass.
May 1-3, 1957

AIEE-IRE-RETMA-WCEMA Electronic Components Conference*
Morrison Hotel, Chicago, Ill.
May 1-3, 1957

East Central-Middle Eastern District Meeting*
Biltmore Hotel, Dayton, Ohio
May 7-9, 1957

Aircraft Electrical Equipment Conference*
Dayton, Ohio
May 7-9, 1957

Domestic Appliances Conference*
Detroit, Mich.
May 20-21, 1957

AIEE-ISA-IAS National Telemetering Conference*
Cortez Hotel, El Paso, Tex.
May 27-29, 1957

Rectifiers in Industry Conference*
Morrison Hotel, Chicago, Ill.
June 4-5, 1957

Summer General Meeting*
Sheraton-Mount Royal Hotel,
Montreal, Que., Canada
June 24-28, 1957

Pacific General Meeting
Pasco, Wash.
August 28-30, 1957
(Final date for †TP—May 28, ‡CP Syn—June 14, CPMs—June 24)

AIEE-IRE Magnetic Amplifiers Conference
Penn-Sheraton Hotel,
Pittsburgh, Pa.
September 4-6, 1957
(Final date for †TP—June 4, ‡CP Syn.—June 19, CPMs—June 28)

Petroleum Conference
Penn-Sheraton Hotel,
Philadelphia, Pa.
September 9-11, 1957
(Final date for †TP—June 10, ‡CP Syn.—June 25, CPMs—July 5)

AIEE-IRE Industrial Electronics Conference
Morrison Hotel, Chicago, Ill.
September 24-25, 1957
(Final date for †TP—June 24, ‡CP Syn.—July 10, CPMs—July 19)

AIEE-IRE-IIT-NU-U of I National Electronics Conference
Hotel Sherman, Chicago, Ill.
October 7-9, 1957
(Final date for †TP—July 7, ‡CP Syn.—July 22, CPMs—Aug. 1)

Fall General Meeting
Chicago, Ill.
October 7-11, 1957
(Final date for †TP—June 7, ‡CP Syn.—July 24, CPMs—Aug. 2)

Feedback Control Conference
Claridge Hotel, Atlantic City, N.J.
October 9-11, 1957
(Final date for †TP—July 9, ‡CP Syn.—July 24, CPMs—Aug. 2)

Reliability and Quality Control in Electronics Conference
Silver Spring, Md.
October 10, 1957
(Final date for †TP—July 10, ‡CP Syn.—July 25, CPMs—Aug. 2)

Machine Tool Conference
Hotel Schroeder,
Milwaukee, Wis.
November 4-6, 1957
(Final date for †TP—Aug. 5, ‡CP Syn.—Aug. 20, CPMs—Aug. 30)

Magnetism and Magnetic Materials Conference
Park Sheraton Hotel,
Washington, D.C.
November 18-20, 1957
(Final date for †TP—Aug. 19, ‡CP Syn.—Sept. 3, CPMs—Sept. 13)

AIEE-IRE-ACM Eastern Joint Computer Conference
Park Sheraton Hotel
Washington, D.C.
December 8-11, 1957
(Final date for †TP—Sept. 9, ‡CP Syn.—Sept. 24, CPMs—Oct. 4)

Winter General Meeting
Hotel Statler,
New York, N. Y.
February 2-7, 1958
(Final date for †TP—Nov. 1, ‡CP Syn.—Nov. 15, CPMs—Nov. 25)

South West District Meeting
Tulsa, Okla.
March 31-April 2, 1958
(Final date for †TP—Dec. 31, §DP Syn.—Jan. 15, DPMs—Jan. 24)

Middle Eastern District Meeting
Washington, D.C.
April 28-30, 1958
(Final date for †TP—Jan. 28, §DP Syn.—Feb. 11, DPMs—Feb. 21)

Summer General Meeting
Buffalo, N.Y.
June 23-27, 1958
(Final date for †TP—March 21, ‡CP Syn.—April 8, CPMs—April 18)

Pacific General Meeting
Sacramento, Calif.
August 19-22, 1958
(Final date for †TP—May 19, ‡CP Syn.—June 3, CPMs—June 13)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
(The CP Syn. date is 10 days before the CPMs date)
§DP Syn.—District Synopsis
DPMs—District Manuscipt
(The DP Syn. date is 10 days before the DPMs date)

of a liquid flow-rate meter, having its sensing elements outside the flow stream, which should meet the needs for reactor and simulated reactor installations.

"Radiation Flux Conditions in Radioactive Media with Applications to Radiation Monitoring" by B. E. Dahlin of the Minneapolis-Honeywell Regulator Company, describes methods used for comparison of sensitivities of common detectors for radiation monitoring of airborne and waterborne radioactivity.

"Dynamic Simulation of a Fast Reactor System" by R. G. Olson of Atomic Power Development Associates, Inc. In this paper, the uses of analog computer techniques for aiding in the prediction of dynamic power plant are outlined, with emphasis on some of the important differences between the thermal and fast reactor simulation programs.

"The Logarithmic-Diode Counting-Rate Meter and Period Meter" by B. B. Barrow of Hycon Eastern, Inc., Cambridge, Mass., which analyzes these instruments, treating the problem of obtaining rapid response to reactor flux transients and discussing the procedure for choosing design parameters.

"A Wire-Activation Technique for Reactor-Flux-Profile Measurements" by A. E. Klickman and F. R. DeFalco of Battelle Memorial Institute, describing the extension of the wire-activation method so that flux profiles can be obtained in the cores of reactors of the pressurized water type. Tests have shown that the method is feasible and the counting rates are sufficiently high to give reliable results.

A paper by C. V. Weaver, C. K. Smith, and J. W. Chastain of Battelle Memorial Institute, entitled "Development of a Thermal Neutron-Flux Measuring Instrument," covering a bridge-type instrument which measures directly and automatically values in the range of 10^{13} to 10^{14} neutrons per square centimeter per second.

"Solid-State Neutron Flux Measuring System" by T. S. Gray and R. H. Spencer of Massachusetts Institute of Technology, W. M. Grim, Jr., of General Electronics Laboratories, Inc., and F. S. Replogle, Jr., of the Schlumberger Well Surveying Corporation. The paper discusses some of the recent applications of electronics to nuclear instrumentation including use of solid-state components, magnetic modulators, and transistors.

"Acoustic Ionization Chamber" by D. R. Whitehouse of Massachusetts Institute of Technology and F. S. Replogle, Jr., which describes an a-c ionization chamber utilizing the acoustic pressure generated within an ionized gas by an applied a-c field. The instrument has a sensitivity of approximately 1.5×10^7 neutrons per square centimeter per second.

"Millimicrosecond Coincident System" by J. G. Lundholm, Jr., J. A. Bjorkland, and A. C. Menius, Jr., of North Carolina State College, covering a system for the measurement of positron lifetime in various solids and liquids. The system uses plastic scintillation phosphors and photomultipliers with wide-band amplifiers and germanium diodes for fast coincidence selection.

"Evolution of Neutron Sensing Elements—Scientific Laboratory to Industrial Application" by L. E. Johnson of Neutronics Laboratory, Finley Park, Ill. The paper reviews the subject of detection for the benefit of new control engineers entering this field, and discusses what is being done in the use of materials, techniques, and design to enable these elements to handle higher fluxes and temperatures.

"Electrical Problems in Electrical Burnout Testing of Nuclear Fuel Elements" by T. W. Hunt of Westinghouse Electric Corporation, which gives a detailed description of electrical equipment used in a burnout test facility and discusses solutions to the various problems that have arisen during the test program.

Exhibits

America's leading producers of atomic reactors, power plants, and equipment displayed a score of scale models of advanced type nuclear reactors for use by civilian industry, research, and medical institutions.

Hundreds of other technical items such as reactor fuels, mechanical arms for handling radioactive materials, latest radiation and detection devices, also were displayed.

In addition, educational exhibits of special interest to the public had been prepared by the U. S. Atomic Energy Commission, universities, and U. S. Department of Commerce, and various independent research organizations. Mainly nontechnical in nature, these exhibits made understandable to the layman in industry, the basic facts about atoms, isotopes, and their many uses to benefit mankind.

An operating atomic reactor said to be "completely safe" was shown publicly for the first time at the Exposition. Developed by Aerojet-General Nucleonics and designated the *AGN 201*, it develops a normal output of 100 milliwatts with a peak of 3 watts. The reactor, which includes a remote control console, is designed for use in hospitals, educational institutions, and industry for production of radioactive isotopes. All shielding required has been built into the reactor so that it is completly self-contained.

Two new particle accelerators for research and industry were photographically displayed by High Voltage Engineering Corporation, Burlington, Mass. One of the new units—a 10 million volt Van de Graaff machine known as a Tandem Accelerator—has been designed especially for use in basic physics research programs. The first model of this machine is to be installed at the Chalk River facility of Atomic Energy of Canada, Ltd. The 35-ton machine—actually two 5 million volt accelerators placed end to end with a common high voltage terminal—will enable study in continuous detail of nuclear energy levels of the heavy elements. Programs of this type were limited until development of the Tandem Accelerator. The other machine featured in the exhibit—a microwave linear accelerator—is one of two types of linear machines being built by High Voltage. One model operates in the 2.5 to 7.0 million electron volt (mev) range and the other operates in the area between 6.0 and 14.0 mev.

The display of Combustion Engineering, Inc. (CE), at the Atomic Exposition and Nuclear Congress related, through the use of pictures and models, its background and current work in the field of atomic energy. It also featured the growth aspect of the company in terms of the expansion of existing facilities and the acquisition of new ones required for the development, design, and manufacture of complete nuclear reactor systems. A large part of the display was devoted to the expanding nuclear facilities of CE, at Windsor, Conn.

Models of two General Electric (GE) nuclear test reactors which the company will supply for the U. S. Air Force's atomic aircraft development program were shown for the first time at the Exposition. The Lockheed Aircraft Corporation is prime contractor for the project for which the test reactors will be supplied. The reactors are being built by the GE Atomic Power Equipment Department, San Jose, Calif. One model is of a shielding development reactor which will be suspended 200 feet above the ground on cables to aid in studies of shielding materials for an aircraft nuclear power plant. The other is a model of a radiation-effects reactor which will be used in testing atomic radiation effects on materials that will be used in this aircraft propulsion project.

Application of the atom for the production of power and for industrial research was shown with 3-dimensional animated models of nuclear reactors by Atomics International (AI), a division of North American Aviation, Inc. Two of the three models

THE FIRST operating nuclear reactor ever exhibited to the public was displayed at the 3rd International Atomic Exposition. Now in quantity production at Aerojet-General Nucleonics, the AGN 201 reactor has been approved by the Atomic Energy Commission as completely safe for public exhibition without special shielding.

shown at the Exposition represented power reactors designed by Atomics International. One is the Sodium Reactor Experiment (SRE), an experimental reactor being built by the company as a part of the AEC program to develop economic power from nuclear energy. Another model represented a new type nuclear power reactor developed for smaller production plants. Designed and to be built by AI, the new reactor, called the Organic Moderated Reactor (OMR), has been selected by American and Foreign Power Co., Inc., for installation in a Latin American country. It is similar to an experimental OMR type reactor being built by AI for the AEC as a part of the AEC's nuclear power development program. The third model represented an industrial research reactor being built for the Japan Atomic Energy Research Institute.

A machine that rolls metal powders directly into strip material made its debut at the Exposition. The mill, designated Model *TAH-400*, was a product of the Nuclear Division of Stanat Manufacturing Co., Inc., Westbury, N. Y. The unit is designed primarily as a tool for processing fuel elements used in nuclear reactors.

New models of a radiation survey meter and a radioactivity research scaler were among the nuclear products shown by Baird-Atomic, Inc., Cambridge, Mass. The radiation survey meter, *Model 414*, features a single logarithmic scale and incorporates a new one-tube circuit design to assure unmatched reliability and long battery life. It can detect and measure X-ray, gamma, and beta radiation. Uses include radiation monitoring in "hot" laboratories and at reactor installations. Baird-Atomic's *Model 215* nonoverloading linear amplifier was also on display. This instrument is used for amplification of pulses from scintillation detectors used in measurement of radioactivity. Because this unit is designed to amplify small pulses in the presence of much larger overload pulses, it is recommended for pulse height analysis of X-rays in the presence of high energy gamma rays. For qualitative or quantitative analysis of one or more isotopes in mixture, Baird-Atomic showed its *Model 513* single channel scintillation spectrometer. Because the unit substantially reduces background count, this instrument can be used effectively for measurement of low concentration or low energy samples.

A model of an electric generating station, nuclear-fueled, and instrumented with Leeds & Northrup electronic measurement and control equipment was demonstrated. The instruments of the electric power portion of the model are identical to those being used by leading power companies to regulate important operating variables, from fuel consumption to final power distribution. The nuclear instruments are representaitve of those actually in use on numerous research and experimental reactors, and the reactor control circuitry involved is based on design techniques developed at various facilities of the AEC. The simulated reactor was a schematic presentation of a boiling water power reactor which eliminates the heat exchange equipment common to other reactor types. Power load requirements of the electric power pool ultimately govern the output of this power reactor system. Changing station requirements result in automatic changes in the boiling rate of the reactor which, of course, increase or reduce steam pressure. This increases or decreases the station generation, because steam pressure controls the main throttle valve to the turbine.

MODEL OF THE FIRST nuclear reactor for the Far East, which is being built by Atomics International, is inspected by Susumu Suguri (*left*) of the Japanese Ministry of International Trade and Industry, and Kiyoaki Taketani (*right*) of Tokyo University, who will use the reactor in their studies. This reactor model, plus two others were displayed at the International Atomic Exposition.

AIEE Philadelphia Section Participates in Nuclear Congress

In co-operation with the Nuclear Engineering Congress held in Philadelphia, Pa., March 11-15, S. C. Townsend, manager, atomic power department, Pennsylvania Power & Light Company, addressed the Philadelphia Section of the AIEE at its March 11 meeting. Included among the 450 people in attendance from 23 states and 7 foreign countries were several AIEE personatities: C. T. Pearce, Westinghouse Electric Corporation, vice-president of District No. 2; N. S. Hibshman, national secretary; R. S. Gardner, assistant secretary; and W. B. Morton, Pennsylvania Power & Light Company, past vice-president of District No. 2.

Mr. Townsend's talk on "The PAR Homogenous Reactor—Plant Design and Operation" described the development of the present design of the reactor from that originally envisioned. He described how changes in operating philosophy resulted in design variations to provide for much direct and semidirect maintenance instead of primarily remote maintenance with its enormous problems. The 150,000 kw (electrical output) unit planned for operation in 1962 is the only large aqueous homogeneous breeder-type reactor now under consideration. The obvious advantage of the breeder type unit is that except for a cost of possibly 2 mils per kwh to remove fission products and poisons, the incremental fuel cost will approach zero. The unit is presently being designed by the Westinghouse Electric Corporation with the assistance of several subcontractors.

The Philadelphia Section also contributed greatly to the success of the Nuclear Congress by assuming through its committee the responsibility of obtaining aides for the technical meetings. G. Beggs, Jr., Leeds and Northrup Company, was chairman of the AIEE-staffed Technical Events Committee. He was assisted by J. L. Cockrell, Leeds and Northrup Company; H. F. Davis, Minneapolis-Honeywell Regulator Company; J. A. Fraunfelder, Leeds and Northrup Company; P. Snyder, Radio Corporation of America; and G. W. Gordon, Philadelphia Electric Company.

In addition, many other AIEE members assumed positions of responsibility in various operating activities of the congress.

The AIEE display booth prepared by National Headquarters was utilized in the general display area at Convention Hall with many engineers from various parts of the country and foreign countries stopping off to chat. Responsibility for staffing the booth was assumed by A. H. Sellers, Philadelphia Electric Company, Section membership chairman, assisted by W. S. Osborne, Atlantic Refining Company, and R. T. Ferris, Philadelphia Electric Company.

Attendance Is High at Computer Fundamentals Symposium

The joint AIEE-Institute of Radio Engineers seven-session symposium entitled "Computer Fundamentals for Computer Engineers" has been an overwhelming success with an advance registration of 450 and the actual attendance even higher. Working under the general supervision of the AIEE Philadelphia Section Educational Committee, headed by W. O. Mascaro, chairman, Atlantic Refining Company, the AIEE members on the Symposium Operating Committee are: R. Better, Philco Corporation; F. H. Fenton, Jr., Leeds and Northrup Company; and Dr. R. S. Berkowitz, advisor, University of Pennsylvania.

Chase Ltd., Photo

THE CHAIRMEN (*above, left*) **of the principal committees for the third annual Symposium on Reliability and Quality Control in Electronics were: (*seated, left to right*) C. M. Ryerson, program chairman; M. M. Tall, general chairman; Mrs. R. Murrell, registration co-chairman; I. Schoeninger, facilities chairman; J. W. Greer, general co-chairman; (*standing, left to right*) M. E. King, finance; R. M. Jacobs, publicity chairman; R. Murrell, registration chairman; J. Clubertson, facilities co-chairman; and P. K. McElroy, transactions chairman. Above, *right*: The Executive Board of the symposium is composed of: (*left to right*) L. Jacobson, chairman Qualifications Acceptance Committee of RETMA; M. M. Tall, general chairman, third and fourth National Symposiums; R. Harris, chairman Reliability and Quality Control Committee of AIEE; A. Mundel, chairman Electronics Division of ASQC; and V. Wouk, chairman Professional Group on Reliability and Quality Control of IRE.**

Chase Ltd., Photo

Third Symposium Held on Reliability and Quality Control

The 3rd Annual Symposium on Reliability and Quality Control in Electronics was held in Washington, D. C., at the Statler Hotel, January 14-16, 1957. It was cosponsored by AIEE, Institute of Radio Engineers, Radio-Electronics-Television Manufacturers Association, and American Society for Quality Control.

Approximately 1,200 people attended this conference, including 26 members of the press and 19 nonresidents of the United States. The program included 30 individual papers, 3 panel sessions, 6 tours, and a total of 65 speakers. The banquet was attended by 1,000 people who listened to Dr. Noble expound on the fantasy of the space man with an unreliable space ship. Through this medium Dr. Noble expressed his views on the concept of reliability as expressed by the armed services of the United States and many of our manufacturing organizations.

The new idea of mailing panel papers and statements of position to pre-registrants worked out extremely well. There were 940 who pre-registered and received this literature so that the panels were devoted to answering questions that were prepared in the confines of the attendees' offices. The answers to the questions and comments will be made subjects of future meetings.

Courtesy R. A. Clemensen

COMMITTEE CHAIRMEN for the AIEE 1957 Pacific General Meeting, Pasco, Wash., August 28-30, are: (*front row, left to right*) L. P. Reinig, registration; Mrs. C. R. Bergdahl, ladies activities; O. W. Hurd, general chairman; H. A. Carlberg, vice-chairman; F. J. Mollerus, finance; (*back row, left to right*) S. M. Rhyneer, secretary; D. W. McLenegan, students program; W. J. Dowis, technical program; F. P. Robinson, hotels and motels; H. A. Brederson, transportation and inspection; R. B. Britton, entertainment; and H. R. Hughes, publicity.

Richland Section Will Be Host to 1957 Pacific General Meeting

The Richland Section of the AIEE will be host this year to the 1957 Pacific General Meeting which will be held in the city of Pasco, Wash., August 28-30. Pasco is located in south central Washington in an area of active hydroelectric development on the Columbia and the Snake Rivers.

The technical program for the meeting will feature power generation and system planning but also will include a well-rounded representation of other subjects of general interest.

Pasco is situated within a days drive of the most famous vacation areas of the Pacific Northwest. Those who find it convenient to drive to and from this meeting will have an opportunity to see some of the most interesting scenery in a region noted for its tourist attractions.

The names and addresses of the committee chairmen for the Pacific General Meeting follow.

Chairman—O. W. Hurd; Mailing Address: P. O. Box 247, Kennewick, Wash.; Business Phone: Justice 2-2175.

Vice-Chairman—H. A. Carlberg; Mailing Address: 1932 Harris, Richland, Wash.; Business Phone: 6-4355.

Secretary—S. M. Rhyneer; Mailing Address: 1917 Howell Ave., Richland, Wash.; Business Phone: 6-4410.

Finance Committee—F. J. Mollerus; Mailing Address: 1218 Green Ave., Richland, Wash.; Business Phone: 6-4942.

Hotels and Motels Committee—F. P. Robinson; Mailing Address: P. O. Box 971, Pasco, Wash.; Business Phone: Liberty 7-5515.

Registration Committee—L. P. Reinig; Mailing Address: 704 Cedar, Richland, Wash.; Business Phone: 2-4532.

Ladies Committee—Mrs. C. R. Bergdahl; Mailing Address: 1802 Hunt, Richland, Wash.; Home Phone: 4-7827.

Technical Program—W. J. Dowis; Mailing Address: 1603 Judson Ave., Richland, Wash.; Business Phone: 6-4532.

Entertainment Committee—R. B. Britton; Mailing Address: 1919 Howell, Richland, Wash.; Business Phone: 3685.

Transportation and Inspection Trip Committee—H. A. Broderson; Mailing Address: 701 Birch St., Richland, Wash.; Business Phone: 6-4696.

Publicity Committee—H. R. Hughes; Mailing Address: 1925 Howell Ave., Richland, Wash.; Business Phone: 6-5035.

Students Committee—D. W. McLenegan; Mailing Address: 1946 Hetrick, Richland, Wash.; Business Phone: 6-4711.

Section Past Chairman Honored

A. E. PAIGE (center), 1955-56 chairman of the AIEE Denver Section is presented with a certificate and past chairman's pin by M. H. Kight (left), present Denver Section chairman, and E. R. Jones (right), vice-chairman of AIEE District No. 6.

Symposium To Be Held at University of Vermont

A symposium on the application of digital computers to problems of analysis and control of power systems will be co-sponsored by the department of electrical engineering of the University of Vermont and the Vermont Subsection of the Pittsfield, Mass., Section of AIEE, May 16-17, 1957, at the University of Vermont. Growing interest in this subject indicates the timely nature of the symposium.

Anyone wishing to present a paper or to obtain a copy of the program should write to Prof. H. M. Smith Jr., University of Vermont, Burlington, Vt.

Successful Conference Held on Transistor and Solid-State Circuits

The 1957 Transistor and Solid-State Circuits Conference was held in Philadelphia, Pa., February 14-15, 1957, at the University of Pennsylvania under the sponsorship of the Science and Electronics Technical Division of AIEE, the Philadelphia Section of the Institute of Radio Engineers (IRE), the IRE Professional Group on Circuit Theory, and the University of Pennsylvania. The record registration of 1,374 persons included engineers and scientists from the United States as well as foreign countries.

The conference program provided a total of 28 technical papers, 4 of which were of a tutorial nature, aimed at surveying recent advances in the subject and providing the practicing engineer in solid-state circuitry a broader picture of the state of the art.

The opening session of the conference offered an address by Dr. A. L. Samuel, this year's national conference chairman, followed by Dr. G. L. Haller, national chairman of the 1956 conference, who presented slide projecting equipment and a selection of books to the Moore School of the University. Dr. J. G. Brainerd, in turn, formally accepted these presents on behalf of the University.

On the evening of the first day of the conference, a series of informal group discussions were held in conference rooms at the Bellevue-Stratford Hotel. As in past years, this feature was well received. Dr. J. A. Rajchman's extension of remarks concerning solid-state devices, a subject which he covered in one of the tutorial sessions earlier that day, was especially noteworthy.

Although no conference proceedings will

THE NATIONAL COMMITTEE of the 1957 Transistor and Solid-State Circuits Conference included: (left to right, seated): G. H. Kunstadt, Radio Corporation of America, publicity committee chairman; M. S. Corrington, RCA-Victor Television Division, chairman of the Philadelphia Section Institute of Radio Engineers; A. L. Samuel, International Business Machines Corporation, national committee chairman; J. C. Logue, International Business Machines Corporation, national committee secretary; (left to right, standing) W. J. Popowsky, Minneapolis-Honeywell Regulator Company, national committee treasurer; G. H. Royer, Westinghouse Electric Corporation, program committee chairman; G. L. Haller, General Electric Company, national committee past chairman; N. A. Koss, General Electric Company, Philadelphia Section AIEE Science and Electronics Technical Division chairman; J. G. Leisenring, General Electric Company, local arrangements chairman.

be issued, there are plans to publish some of the papers in a forthcoming issue of the *Transactions* of the IRE Professional Group on Circuit Theory. An innovation of this conference which proved extremely popular with all registrants was the distribution of a booklet containing reproductions of all slides, including mathematical expressions used by the speakers.

Because of the success of this meeting, and of the three previous Transistor Conferences, early plans are now being made for the next one, expected to be held in Philadelphia in early 1958.

Michigan Section of AIEE Hears Talk by Dr. Kirchmayer

Members and guests of the Michigan Section of the AIEE heard Dr. L. K. Kirchmayer, manager of the Power Systems Operational Investigations Unit of General Electric Company, give a talk on "How Modern Tools Improve Power Systems." The speech was delivered at a dinner meeting held on Tuesday, February 12, 1957, at the First Methodist Church in Jackson, Mich.

Dr. Kirchmayer pointed out that recent developments in analytical methods, computers, and load controls have saved the electric utility industry millions of dollars annually in operating costs. He also stated that innumerable combinations of operating conditions can occur in large integrated systems because of varying fuel costs and frequent interconnection transactions, so that the precalculated schedules covering these conditions becomes very large, and specialized computers particularly designed for the load dispatcher may be justified economically.

He pointed out that existing economic automation schemes permit each area of a power system to maintain automatically its own frequency, a predetermined and preset net interchange, and economic allocation of generation. But, in the future, complete economic automation of power pools formed by several areas or companies will eliminate the need for manually determining and setting the most economic interchange of each particular company. With the electric utility operations doubling every 10 years plus the present and projected shortage of scientific personnel, engineering manpower problems become increasingly critical and computers, together with people trained in analytical and computing techniques, provide a means for meeting these challenges.

A. W. Rauth of Consumers Power Co., past chairman of the Section, gave the invocation preceding the dinner. A brief business meeting was presided over by Fred Von Voigtlander, chairman of the Michigan Section, during which he stressed the functions of the educational committee and the plans for the coming "Nuclear Power" Classes.

B. T. Miller of General Electric Company was in charge of the program and introduced the speaker. T. Niessink, of Commonwealth Associates Inc., member of the Entertainment Committee, and H. Sinclair of Consumers Power Co, a member of the Contact Committee, assisted with the arrangements.

EJC Publishes Report on Professional Income of Engineers

A report entitled "Professional Income of Engineers—1956" was issued recently by Engineers Joint Council (EJC).

Prepared by the EJC Special Surveys Committee, made up of M. M. Boring (chairman), D. S. Bridgman, G. A. Hathaway, E. C. Easton, H. R. Beatty, and A. W. Rathe, this is the second triennial report on the subject of engineering incomes.

In 1953, realizing the need for a comprehensive study to evaluate the earning potential and general salary status of the engineer, EJC undertook the first in a series of professional income surveys. In this study, the sample included 69,061 engineers in industry and Government and 2,977 in engineering education.

The current survey, conducted in the same manner as in 1953, based on an expanded sample, presents a comprehensive analysis of the earnings of engineering graduates in the major fields of engineering employment.

Information for this survey was received for a total of 107,832 engineering graduates employed in industry, Government, and engineering education. The breakdown is as follows:

Replies: industry—346 firms; Federal Government—10 agencies; state and local governments—28 agencies; education—4,081 individual replies

Engineering graduates: industry—93,123; Federal Government—5,078; state and local governments—5,550; education—4,081

The sample represents 17.5% of the estimated engineering graduate population of 625,000 employed in the United States. Each employment activity is represented as follows: industry—18.5%; Government—7%; engineering education—34%.

The tables and charts that make up the body of the report present the analysis of information received in both graphic and tabular form.

The basic salary information obtained from the employer in industry and the Government covers earnings for all employed engineering graduates, classified by the year in which the baccalaureate degree was awarded as well as the current starting salary rate for engineering graduates. Special tables are included for engineers holding Ph.D. and Sc.D. degrees.

Earning scales are shown in 13 major industrial employment areas, including chemicals and allied products, electrical machinery, transportation equipment, railroads, telecommunication services, public utilities, etc. For engineers in education, both teach-

Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held in Montreal, Que., Canada, at 2:00 p.m., Monday, June 24, 1957, during the Summer General Meeting.

At this meeting, the annual report of the Board of Directors and the reports of the Committee of Tellers on the ballots cast for the election of officers and for the proposed amendments to the AIEE Constitution will be presented. The Lamme Medal will be presented to Harold H. Beverage (AM '23. M '34, F '48).

Such other business, if any, as may properly come before the annual meeting may be considered.

Signed N. S. HIBSHMAN
Secretary

MEMBERS at the speakers table during the Michigan Section Meeting were: (*left to right*) B. T. Miller, General Electric Company, Jackson, Mich.; Dr. Kirchmayer, speaker for the meeting; Fred Von Voigtlander, Cummins and Barnard, Ann Arbor, Mich.; and H. M. Hess, Wayne State University, Detroit, Mich., secretary-treasurer of the Michigan Section.

ing income and outside income are indicated.

Included in the booklet is an appendix containing the questionnaires used for the survey.

The 36-page booklet is available from Engineers Joint Council, 29 West 39th St., New York, N. Y., for $1.50 per copy.

Dr. L. M. Goldsmith Named Philadelphia Engineer of the Year

Dr. L. M. Goldsmith (F '47), general manager of engineering and construction, The Atlantic Refining Company, was cited by the Pennsylvania Society of Professional Engineers in co-operation with other affiliated engineering societies, as the Philadelphia Engineer of the Year.

Presentation of the award was made by A. H. Kidder, vice-president of the National Society of Professional Engineers, at a luncheon at the Engineers' Club, highlighting the celebration of National Engineers' Week.

Dr. Goldsmith, a graduate of Drexel Institute of Technology, who has just completed 40 years of service with his company, was cited by Mr. Kidder for ". . . his outstanding contributions to the Advancement of the Petroleum Industry, the Engineering Profession, and in the service of his country."

In an address of acceptance, Dr. Goldsmith urged young engineers of today to avail themselves of further education if they are looking toward advancement into the higher ranks of management.

Dr. Goldsmith pioneered the application of electric welding in the construction of pipelines and ocean-going tankers. He engineered the development of the first high-

AT A LUNCHEON held at the Engineers' Club, Philadelphia, Pa., highlighting National Engineers' Week, Dr. L. M. Goldsmith (*center*), general manager of engineering and construction of The Atlantic Refining Company, was cited as "Philadelphia Engineer of the Year." A. H. Kidder (*left*), vice-president of the National Society of Professional Engineers, made the presentation. Observing is J. L. Bahr (*right*), National Engineers' Week chairman.

pressure, high temperature, turbine driven tankers.

During World War II, he served as a member of Division 12, National Defense Research Committee, Office of Scientific Research and Development, and as expert consultant for the War Department. He was the original chief engineer of the war emergency pipe lines. He also worked with the British Ministry of War on loan from the U. S. Army Corps of Engineers, and was flown overseas to participate in the development of their project PLUTO, by which flexible pipelines were successfully extended across the English Channel to facilitate delivery of petroleum products directly from England to France to the allied fighting forces. For this last achievement, Dr. Goldsmith received the Exceptional Civilian Service Medal which is the U. S. Army's

Two Distinguished Awards Presented

Leon Trice, Photography

Leon Trice, Photography

AT THE RECENT ANNUAL MEETING of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) in New Orleans, La., two distinguished awards were made. *Above, left:* Herbert Hoover, Jr., (*right*), former Under Secretary of State, receives the Hoover Medal, named after his father, who was its first recipient. One of the profession's top honors, it is co-sponsored by AIEE, AIME, American Society of Civil Engineers (ASCE), and American Society of Mechanical Engineers (ASME). Presenting the award is H. DeWitt Smith (*left*), former AIME president. *Above, right:* Mohamed Mortada (*left*), senior engineer, Magnolia Petroleum Co., Dallas, Tex., receives the Alfred Noble Prize. Co-sponsored by AIEE, AIME, ASCE, ASME, and Western Society of Engineers, it was awarded for a petroleum technical paper of outstanding merit. Presentation was made by C. E. Reistle, Jr., outgoing AIME president, vice-president of Humble Oil & Refining Company.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until May 27. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before May 27.

56-789 Discontinuous Transition Time between Stable States in Ferroresonant Circuits. *Sheldon Plotkin*

56-802 A New 5-Channel Carrier System for Subscriber Use Employing Transistors. *B. R. Stachiewicz, R. L. Layburn, D. F. Jamieson*

57-22 Report on Lightning Arrester Applications for Stations and Substations. Working Group, Lightning Protective Devices Subcommittee of the AIEE Protective Devices Committee

57-26 Motor-Operated Switch for Space-Heating Control. *J. C. Beckett*

57-33 Design of Ignitron Tubes for Rectifier Locomotives. *B. E. Belnap, J. L. Zehner, H. E. Zuvers*

57-69 Substation Design Standards and Shortcuts Save Manpower. *R. F. Stevens*

57-129 Effect of Clearing Time on Synchronous Machine Transient Stability. *G. Shackshaft, A. S. Aldred*

57-178 New Line of High-Power Interrupters for Breakers Rated 69 Kv and Above. *A. W. Hill, R. E. Friedrich*

57-183 The Response of Relay Amplifiers with Feedback. *J. E. Gibson, F. B. Tuteur*

57-219 Dynamic Balancing of Hydroelectric Units. *H. N. Hill, R. S. Barker, J. R. Murtland*

57-228 D-C Metering of Large Electrochemical Pot Lines. *M. E. Reagan*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

highest civilian decoration. In addition, he received the Certificate of Merit from the President of the United States for outstanding services in World War II.

Dr. Goldsmith is responsible for the world's first class of 30,000 deadweight ton super tankers used in the oil industry. He is, at present, serving as a member of the Scientific Advisory Panel, U. S. Army Transporation Corps, Department of Defense, and also as engineering consultant for the Transportation Research and Development Command.

Los Angeles Section Addressed by Dr. Suits

"Research methods themselves, and the vastly improved quality and quantity of modern exploratory tools, permit scientists to predict those areas of engineering technology in which significant advances and break-throughs may be confidently expected in the near future." This keynote served to lead Dr. C. G. Suits into his highly absorbing address before the general meeting of the Los Angeles Section of AIEE, held March 12 at the Friday Morning Club.

Dr. Suits, vice-president of the General Electric Company and director of research, spoke before a capacity audience of over 200 members and guests on many items prominent in his company's program, any one of which might properly have been the subject of a complete session.

GE Research Laboratory

Dr. C. G. Suits

The growth of United States research efforts (from less than $1 billion in 1941 to four times that amount in 1951, and the breadth of application of current sums to all fields of the electrical industry) introduced the speaker's remarks on developments in fuel cells, fusion, and solar converters for generation, electronic refrigeration at junctions utilizing the Peltier effect, revolutionary insulations through radiation of presently known materials, and recent experimental work in metal crystals of purities, and properties, unrealized in theory, which may lead to revolutionary changes in metals handling, working, forming, finishing, and application.

Citing the classical development, in sequence, of gas laws, liquid laws, and solid laws, Dr. Suits stated that the current laboratory work in solid-state physics has outstripped formal study. In an interesting contradiction of modern practice, it is found that perfectly pure specimens of given metals vastly outstrip their allowed counterparts in strength characteristics.

The speaker's liberal use of slides, illustrating facilities, and examples of current work, brought into sharp focus the continuously changing picture of United States scientific and engineering effort. In pointing out the brief time span of activities in atomics, antibiotics, electronics, and other recently emerged fields now grown to giant size, Dr. Suits emphasized that the immediate future would see no slackening of the technical pace; that, although some developments may consume years in perfection or marketability, the demand for easier, faster, and cheaper methods will generate new jobs, new industries, and new opportunities for all.

Dr. Suit's address was considerably extended in the informal question period which followed; sponsoring Power Division Chairman George Davis and Section Chairman P. L. Savage closed the highly successful meeting.

The dinner preceding the address was presided over by Mr. Savage, who introduced the officers present, and who acknowledged introduction from the floor of student guests from several California universities.

J. B. Cottell Speaks at Recent AIEE Meeting

At a recent monthly meeting of AIEE members in Newark, Ohio, the importance of adequate industrial electrical systems was stressed in a talk by J. B. Cottell, president of the Continental Electric Equipment Company, Cincinnati, Ohio, guest speaker for the meeting.

Mr. Cottell's address, "The Path of Power," was about electrical power distribution systems as applied to industrial plants. Also emphasized in the talk was the necessity for more flexible system designs for the improvement of industrial productivity.

The co-chairmen for the meeting were Carl Nagle and Joe St. Andre, both of the Kaiser Aluminum Company's Newark Works.

Two AIEE Committees Sponsor Rectifiers in Industry Conference

The AIEE Joint Conference on Rectifiers in Industry, sponsored by the Semiconductor-Metallic Rectifier and Industrial Power Rectifier Committees, will provide an opportunity for both users and manufacturers to discuss semiconductor and mercury arc rectifier equipment now used in power service by United States industry. The conference will be held June 4-5, 1957, at the Morrison Hotel, Chicago, Ill.

The Executive Committee for the conference includes M. M. Morack and Glen Ramsey, co-chairmen; Tracy Johntz, treasurer; H. W. Cory, program; C. S. Hague, publicity; D. W. Borst, papers and publications; E. H. Whitehead, Chicago Section chairman; and J. N. Banky, conference chairman.

Advance registration for the conference can be mailed to H. B. Bunce, c/o Westinghouse Electric Corporation, Merchandise Mart, Chicago, Ill. Registration fee is $4 for AIEE members, $5 for nonmembers. Checks should be made payable to Tracy Johntz, conference treasurer.

All papers presented at the conference will be published in a bound booklet which will be available at the registration dask at $4 per copy. This booklet may also be ordered from AIEE Headquarters, 33 W. 39th St., New York 18, N. Y., attention Mr. R. S. Gardner.

A block of rooms large enough to accommodate the expected attendance at the conference has been reserved by the Morrison Hotel management. Advance hotel reservations can be mailed to the Reservation Desk, Morrison Hotel, Chicago, Ill.

The tentative technical program for the conference follows:

Tuesday, June 4

9:30 a.m. Morning Session

Address of Welcome: J. N. Banky, Allis-Chalmers Manufacturing Company, chairman

Statement of Conference Purpose. Glen Ramsey, Fansteel Metallurgical Corporation

Semiconductor Rectifiers—Past, Present, and Future. *Glen Ramsey*

An Evaluation of Power Conversion for Industry. *M. M. Morack,* General Electric Company

Applications of New Designs of Ignitron Rectifiers. *F. L. Kaestle,* General Electric Company

A Review of Semiconductor Rectifier Technology in Europe. *E. A. Harty,* General Electric Company

NEMA Specifications on Semiconductor Metallic Rectifiers. *L. W. Burton,* General Electric Company

Mercury Arc Rectifier Standards. *H. Winograd,* Allis-Chalmers Manufacturing Company

IEC Semiconductor Standards and the Munich Meeting. *I. R. Smith,* Westinghouse Electric Corporation

12:00 Noon Luncheon

2:00 p.m. Afternoon Session

Field Testing of the Sealed Ignitron. *E. J. Remscheid, L. Malewicz,* General Electric Company

The Mercury Arc Rectifier and the Hydrogen Ion. *N. F. Marty, E. J. Remscheid*

Analysis of Ignitron Rectifiers for Reversing Mill Drives. *C. G. Hagensick, E. J. Cham*

A New Package Rectifier Designed for Electrochemical Service. *J. W. Luoma,* General Electric Company

Application and Design of Excitron Rectifiers. *A. D. Milliken,* Allis-Chalmers Manufacturing Company

Wednesday, June 5

9:00 a.m. Morning Session

Chairman: D. E. Trucksess

A 10-Kw Germanium Rectifier for Automatic Power Plants. *E. A. Hake,* Bell Telephone Laboratories

Application of Selenium Rectifiers to Turbogenerator Excitation. *W. Egan, R. Robertson,* Allis-Chalmers Manufacturing Company

***The Application and Rating of a Silicon Power Rectifier.** *D. K. Bisson,* General Electric Company

***Silicon Power Rectifier Equipment.** *J. A. Marshall, V. N. Stewart,* General Electric Company

†**A High Current Density Selenium Rectifier.** *C. C. Geib, W. E. Brown,* Fansteel Metallurgical Corporation

†**Selenium Rectifier Applications in Automotive Vehicles.** *E. J. Szabo,* Leece-Neville Company

Germanium Rectifier Equipment for Electrolytic Processes. *L. G. Miller, W. R. Hodgson*

12:00 Noon Luncheon

2:00 p.m. Afternoon Session
Chairman: G. N. Zins

A 225 Amp. Silicon Rectifier in a Welding Application. *Dr. W. B. Green*

A New Excitron Variable Drive. *A. J. Humphrey, K. L. Shrider*

3:00 p.m. Panel Discussion
Moderator: G. N. Zins
Panel Members: R. T. Lucas, D. E. Trucksess, R. W. Wagner, R. Scott

* †—These papers are related; presentation will be joint to conserve time. Papers will be published in full.

Past Chairman Certificate Presented

Courtesy Lenscraft Photos, Inc.

AT A RECENT MEETING of the AIEE Boston Section, L. T. Jester, Jr. (second *from left*) received the Past Section Chairman's Certificate from W. A. Carlson (*right*), Section vice-chairman. Observing the presentation are J. C. Hitt (*left*), chairman, Internal Publicity Committee, and H. W. Evirs, Jr. (second *from right*), secretary-treasurer. Mr. Jester's business responsibilities required him to move from the Section location.

Dr. Buttolph Named Officer of National Noise Abatement Council

Dr. L. J. Buttolph (M '35, F '42), well-known electrical engineer, has been appointed executive secretary of the National Noise Abatement Council, President Martin Hirschorn has announced. Dr. Buttolph, who is a resident of Cliffside Park, N. J., recently retired from the General Electric Company after 38 years of service, largely in the field of illumination.

Dr. Buttolph pioneered in the development and use of mercury lamps and holds a great many patents on various inventions and discoveries in that branch of engineering. He has published a large number of papers on discharge lamps and the applications of ultraviolet energy.

In his new post, Dr. Buttolph will direct the Council's efforts to reduce or eliminate the noise plague in industry, city streets, offices, and homes through the promotion of National Noise Abatement Week, sponsorship of annual noise symposiums, award of Achievement Plaques to cities conducting outstanding educational noise reduction campaigns, awards of merit to industries with noise abatement programs, and dissemination of information on noise reduction to city officials, industries, educational

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry,* and *Power Apparatus and Systems,* contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

institutions, and individuals. The Council was organized in 1941 and since has spearheaded the cause of noise reduction.

In accepting the appointment, Dr. Buttolph said that he was happy for the opportunity of following up years of combating air pollution through the use of ultraviolet light, with a position which will allow him to participate in activities against another health problem—excessive noise.

Dr. Wolff Predicts New Development in Color Photography

A high-speed system of electronic color photography that would provide permanent prints of pictures taken less than five seconds earlier at points thousands of miles away has been predicted by Dr. Irving Wolff, vice-president, research, of the Radio Corporation of America.

Speaking to the Boston Section of the AIEE, Dr. Wolff pointed out that techniques now exist for performing all steps in the photographic process by instantaneous electronic means "from exposure to final print, and including the means for storing images in electrical form on magnetic tape."

"We can now foresee future systems in which television cameras, magnetic tape recording equipment, and electronic printing techniques will be linked in various ways to provide versatile high-speed chains with many applications in the home, in industry, and in defense," said Dr. Wolff.

"With such a system, for example, a newsworthy event in New Orleans, San Francisco, Chicago or another city might be viewed by a portable television unit carried by a single newsman. The image would be transmitted instantaneously from the portable unit to a nearby relay point for transmission over a closed circuit or the network facilities to New York or Boston, where the image could be recorded electronically on magnetic tape as it arrived.

"The tape recording could provide a motion-picture record for instant viewing or later playback and rebroadcast. At the same time, any single section of the tape, corresponding to a single frame of the television picture, could be played back repeatedly at high speed to provide a 'still' that could be printed electronically on paper directly from a special type of television picture tube. In this case, the entire process, from exposure in the distant city to the final print in New York or Boston, would take some seconds."

COMMITTEE ACTIVITIES

EDITOR'S NOTE: ***This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.***

Communication Division

Communication Theory Committee (L. G. Abraham, *Chairman*, R. K. Hellmann, *Vice-Chairman*, W. R. Bennett, *Secretary*). This Committee is still building up interest in information theory and other forms of communication theory. It is the intention to appeal to the high-caliber general electrical engineer who is interested in modern theory, but is not a specialist in that field. Suggestions would be welcomed.

The Committee has sponsored sessions at all general meetings this operating year, including the Fall, Winter, and Summer General Meetings. The papers have been varied in subject and method of presentation. Considerable interest has been expressed and the sessions have been unusually well attended. We feel that these sessions fulfill a real need and are particularly appealing to the younger engineers.

Industry Division

Industrial Control Committee (L. H. Matthias, *Chairman;* J. W. Picking, *Vice-Chairman;* E. E. Moyer, *Secretary*). A draft of a Test Code for Industrial Control has been submitted to the Standards Committee for approval. This proposed test code for industrial control is intended to provide standard methods and procedures for making certain tests on industrial control devices rated 600 volts or less and covers what is generally considered as low-voltage industrial control equipment.

There is great need for this test code inasmuch as at the present time no established, standardized, generally accepted procedures exist for making the tests covered by this proposed code, and agreement on methods of test between various laboratories are on a word-of-mouth basis. The test procedures followed by inspection authorities are nowhere defined and misleading results are frequently reported. This test will resolve the confusion and provide methods of test which are considered by the Subcommittee on Test Codes of the Industrial Control Committee, who has worked on the preparation of this code for many years, and also the main Committee who has approved it, to provide simple unambiguous procedures utilizing well-known and readily available test equipment which will produce significant results that may easily be duplicated in other laboratories.

The Subcommittee on Test Codes of the Industrial Control Committee was organized in 1946, and thus has been in existence about as long as the main Committee. The present membership of this Subcommittee is as follows: F. C. Iglehart, W. E. Pakala, H. E. Rhoads, T. K. Knapp, C. A. Schaefer, and C. T. Evans, chairman.

The original chairman of the Subcommittee on Test Codes was Dr. L. T. Raider, who, until he resigned from the Subcommittee chairmanship, did a considerable amount of work in organizing the Subcommittee and preparing the way for the work which has been done. Although the membership of the Subcommittee has altered some over the years, Mr. Evans has been chairman since 1947. During all these years the Subcommittee has been actively concerned with the preparation of this test code. A great deal of effort has been made by the Subcommittee members, and particularly the chairman, to write a test code which would incorporate simple, usable procedures and would still give reliable and significant results. They have consulted the main Committee from time to time and have submitted sections of the test code to the main Committee for their comments, which have been incorporated in or considered in the final draft which has now been submitted to the Standards Committee.

The Subcommittee on Electronic Control under the chairmanship of E. E. Moyer is continuing its work on revisions of the Proposed Standard for Electronic D-C Motor Controllers, a report on which was presented as a Conference Paper at the Winter General Meeting in 1956. The proposed standard was subsequently submitted to the main Committee for comment, and the revisions which are now taking place are the result of comments received.

A new Subcommittee on Motor Protection has been formed under the chairmanship of A. H. Myles. It is intended that this Subcommittee will work with the corresponding Subcommittee of the Relay Committee in the Power Division in a general effort to outline application and standard requirements for overload protective devices.

A Subcommittee on Static Switching is being formed under the chairmanship of W. A. Alvarez. The object of this Subcommittee is:

> "The treatment of those matters relating to the design, construction, performance, and application of, also the definitions, standards, and specifications pertaining to, control circuit static switching devices and systems."

Committee on Mining and Metal Industry (R. B. Moore, *Chairman;* F. R. Hugus, *Vice-Chairman*). The continuing high level of activity in the coal mining industry is reflected in the increased interest and participation in Eastern Mining Subcommittee activities. Two sessions were sponsored at the 1956 Fall General Meeting in Chicago, Ill., one on silicone insulation in mining motors and another on motor maintenance, hoists, shovels, and grounding, each of which were attended by about 50 men.

Preparations are being made for two sessions for the 1957 Fall General Meeting. Papers on mine lighting, shuttle cars, effici-

ency loss effects on heating in motors and cables, voltage variation effects, trolley phones, circuit breaker settings, and similar subjects are being solicited and a good attendance is expected.

Considerable interest is being shown in the use of alternating current in mines. It is felt that the mining industry will benefit from a special technical conference or from several sessions dedicated to this subject and efforts are being made to culminate such plans within the forthcoming year.

Power Division

Committee on Substations (W. S. Scheering, *Chairman;* J. A. Smith, *Vice-Chairman;* A. F. Sedgwick, *Secretary*). In addition to the eight projects which this Committee has been carrying on, two new projects were approved at the meeting held in New York, N. Y., on January 23. The new projects were "Use of Aluminum for Substation Buses" and "Considerations Pertaining to Location and Design of Substations as Related to Neighborhood, Community and/or Planning Commission Attitude and Acceptance."

It is expected that the Working Groups on "Fire Protection and Minimizing Fire Hazards in Substations" and "Design and Utilization of Mobile Substations" will have completed their investigations and have a report available for presentation at a technical session during the Winter General Meeting of 1958.

Plans also are being formulated for holding a round table discussion at some time in the near future to discuss general problems pertaining to design, operation, and location of substations. A similar meeting was held during the week of the Fall General Meeting at Chicago, Ill., in 1955 which was well attended and had excellent participation.

The Committee has scheduled a technical session at the Summer General Meeting in Montreal, Que., Canada, and the West Coast Subcommittee has undertaken solicitation of papers and expects to sponsor a full or joint technical session at the Pacific General Meeting which will be held in Pasco, Wash., August 28-30, 1957.

Liaison representation is being maintained by this committee with the Standards Committee and with working groups under the Committee on Transmission and Distribution and the Committee on Telemetering.

Committee on Switchgear (J. C. Woods, *Chairman;* C. A. Woodrow, *Vice-Chairman;* F. W. McCloska, *Secretary*). The Low Voltage Air Circuit Breakers Subcommittee will present the results of its study of methods of qualification of faults in d-c circuits in a series of papers during the Summer General Meeting.

Recommendations of changes to American Standard *C37.1*, relating to standard operating duty, rated interrupting time, and rated interrupting current, have been sent to the Committee on Standards.

A definition of Metal Enclosed Load Interrupter Switchgear has been approved and submitted to the Committee on Standards with recommendation that it be included in American Standards *C37.20* and *C42*.

The work of the Working Group on the New Method of Rating Power Circuit Breakers is progressing actively. J. H. Vivian has recently been appointed chairman of this group.

Revisions of AIEE Standards No. 22 and No. 25, consisting chiefly of the addition of test guides, have been completed by the Subcommittee and submitted for ballot to the Committee on Switchgear.

Committee on System Engineering (R. T. Purdy, *Chairman;* C. N. Metcalf, *Vice-Chairman;* A. P. Fugil, *Secretary*). The Committee on System Engineering is one of the few places in the AIEE where problems pertaining to the actual operation of an electric power system are considered. The Committee has been studying such problems and has found that considerable interest was evidenced in sessions covering such items as the effect of speed governors on tie-line and frequency control, automatic dispatching and load control, and forced outage rates for high pressure steam turbines and boilers.

The System Controls Subcommittee is completing arrangements for two interesting sessions on load-frequency control and the determination of incremental heat rates as they are applied to automatic dispatching systems, for the Fall General Meeting in 1957.

Studies involving the application of digital computation to system engineering problems, the effect of interconnections on generator expansion and operations research determination of generation reserves, mathematical aspects of fixed charges, and a new approach to loss minimization in electric power systems have been well received.

Attention is called to two reports, the "Survey of Arc Furnace Installations on Power Systems and Resulting Lamp Flicker" (which will soon be published in *Transactions*) and Special Publication S-90 which provides reprints of eight papers on Computer Application to Power System Problems, which is available from AIEE for $1.75.

The program for the Summer General Meeting in Montreal, Que., Canada, will cover economic justification for interconnecting facilities, a simplified basis for applying probability methods to generator capacity requirements, and other papers in the application of digital computation to power system problems.

In order to prevent duplication of effort, the Computer Applications Subcommittee of the AIEE Committee on System Engineering is planning to collect and publicize a list of digital computer programs which have been programmed and checked out. These will be programs for any available commercial computer.

It is intended to give a brief description of the function of the program, who has written it, whether or not it is generally available and the name of an individual or organization which may be contacted for further information regarding it.

If any readers of *Electrical Engineering* are familiar with programs, which might be subroutines, interpretive routines, mathematical routines, or solutions of specific engineering problems and would be willing to supply information at least that such programs exist, please forward this information to either of the following members:

F. J. Maginniss, Manager
Special Engineering Investigations
General Electric Company
1 River Road
Schenectady 5, N. Y.

E. F. Ormsby
IBM World Trade Corporation
807 United Nations Plaza
New York 17, N. Y.

Committee on Transmission and Distribution (T. J. Brosnan, *Chairman;* I. B. Johnson, *Vice-Chairman;* J. T. Lusignan, Jr., *Secretary*). Salient features and accomplishments from the activities of the Committee on Transmission and Distribution and its Subcommittees and Working Groups discussed at the last meeting of the Committee during the Winter General Meeting of the AIEE are the following:

1. The Committee on Transmission and Distribution unanimously agreed that AIEE approve the standardization of the voltages of 345 kv nominal and 362 kv maximum, proposed by Technical Committee No. 30, International Electrotechnical Commission.
2. A report was made to the effect that as the consequence of an agreement on clearance requirements for voltages above 100 kv, American Standard Association Committee C2, working on a revision of the National Electric Safety Code, will meet shortly to complete its assigned task.
3. In response to particular industry-wide interest in these areas, symposiums are being planned at forthcoming meetings of the AIEE on "Use of Silicones or Other Oils or Waxes on Insulated Surfaces for Operation in Contaminated Areas," on "Abnormal Frequency of Flashover from Lightning of High Voltage Lines," and on "Underground Corrosion of Components of Transmission and Distribution Facilities."
4. The Working Group on Switching Surges, in presenting its first committee report as a *Transactions* paper, emphasized the need for field data to balance the large amount of data accumulated from studies on systems in miniature. The subject of switching surges is one of primary current interest in the problem of reduced insulation and insulation co-ordination at transmission voltage levels.
5. Under "What's New in T and D," interesting comments were given by L. H. J. Cook, of B.C. Engineering Company, Ltd., on a 132-kv submarine cable installation between Vancouver Island and the lower mainland of British Columbia. Using longer continuous lengths of cable than heretofore used elsewhere, two 14.5-mile and one 3-mile stretches of gas pressure (nitrogen) type cable were installed. In addition, Mr. Cook described the installation of a two-mile overhead conductor crossing at a point

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

in the channel which was too deep (300 fathoms) for a submarine cable. The crossing is believed to be the fourth longest in the world.

On a different subject, F. A. Cox, of Commonwealth Edison Company, presented an interesting commentary on the introduction of a 12-kv distribution on the Commonwealth Edison Company system. Present load growth has raised difficulties of providing for a large number of 4-kv circuits and distribution centers requiring a large amount of manpower. It was decided to make more general use of 12,000 volts as the primary distribution voltage level. At this level, distribution centers and feeders would provide capacities three to four times as large as those possible with a 4,000 volt system. Problems, nevertheless, arise with the new voltage level. Among these are the development of equipment to handle fault currents ranging from 3,000 to 10,000 amperes, circuit breakers with clearing times in one to three cycles to avoid conductor burndown, and techniques for live line work on aerial and buried cables.

Science and Electronics Division

Committee on Electrical Techniques in Medicine and Biology (T. H. Rogers, *Chairman;* H. P. Schwan, *Vice-Chairman;* W. S. Lusby, *Secretary*). This Committee has recently organized a Subcommittee on Air Pollution, the scope of which is to include investigation and co-ordination of activities of interest to the electrical industry in connection with the growing problems associated with air pollution. J. C. Beckett of San Francisco, Calif., has been appointed chairman of this Subcommittee, and is organizing technical sessions for the coming Pacific General Meeting and also the 1958 Winter General Meeting. Anyone interested in activities of the Institute coming within this scope should communicate with Mr. Beckett.

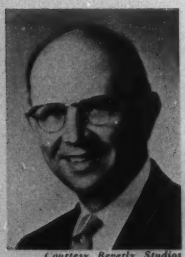
AIEE FELLOWS ELECTED

Board of Directors Meeting, January 25, 1957

Victor Henry Braunig (AM '30, M '42), general manager, City Public Service Board, San Antonio, Tex., has been transferred to the grade of Fellow in the AIEE ". . . for his leadership in design and operation of thermoelectric generating stations and in the management of a large electric utility." Mr. Braunig was born in Hallettsville, Tex., May 22, 1890, and received his B.S. degree in E.E. from Texas A&M College in 1910. After graduation, he joined the San Antonio Public Service Company as a cadet engineer. He has been with that utility and its successor, the City Public Service Board, continuously except for two years service during World War I in the U.S. Army. After the war, he returned to the San Antonio Public Service Company where he has served as superintendent of production, general superintendent, assistant general manager, and general manager. He has held his present position as general manager since 1949. In his capacity as superintendent of production, Mr. Braunig pioneered, in Texas, the use of high pressure and high temperature topping turbines to raise the efficiency of old low pressure generating units. His outstanding accomplishment is the completely centrally operated supervisory control of the San Antonio Electric System utilizing carrier current and microwave channels. Mr. Braunig also handled the first 138-kv oil pipe cable installation in the Southwest. In addition to his accomplishments in engineering and operation, he has done an outstanding job of management and financing in the development of the San Antonio Electric and Gas Systems. During his administration, the load has more than tripled, and is now growing at a rate requiring a greatly accelerated construction schedule. Mr. Braunig is a registered professional engineer in the State of Texas.

Volney Judson Cissna (M '30), electrical engineer, Tennessee Valley Authority (TVA), Chattanooga, Tenn., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to the engineering of a large power transmission system." Mr. Cissna was born in Nevada, Mo., September 1, 1891. He received a B.S. degree from the University of Kansas in 1914. From 1915 to 1918, he was superintendent of municipal water and light plants for towns of 1,100 to 5,500 population in Kansas. In 1918, he was employed by the Empire Gas and Fuel Company, a Cities Service subsidiary, in the Butler County Kansas oil fields. From 1921 to 1929, he served as general meter engineer and later assistant superintendent of transmission for the Kansas Gas and Electric Company. In 1929, he became assistant electrical engineer for the Electric Bond and Share Company, New York, N. Y. From 1934 to 1936, he served as assistant electrical engineer, U. S. Engineer Office, Missouri River Division, Kansas City, Mo., on the Fort Pack Dam project. Since 1936, he has been with TVA as system studies engineer and technical assistant to the Branch Chief, System Planning Branch, Division of Power Engineering and Construction. His duties involve the general supervision of all studies made on the TVA's large a-c network analyzer; serving as consultant to other engineers of TVA on major technical problems; and working with the engineers of municipal, co-operative, and industrial customers of TVA on joint technical problems. Mr. Cissna has been a contributor to the section on Power Transmission of seventh and eighth editions of the Standard Handbook for Electrical Engineers. He is a past chairman of the AIEE Chattanooga Section and is presently a director of the East Tennessee Section. He has served on the AIEE Protective Devices Committee (1947-51).

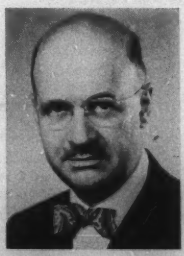
Anatole Rodolph Gruehr (M '30), head of the department of Economics and History, Polytechnic Institute of Brooklyn, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for his application of economic theory to engineering design." Dr. Gruehr was born in Istanbul, Turkey, February 20, 1897. He received the B.S. degree in E.E. from Massachusetts Institute of Technology in 1924 after transferring in 1921 from the Eidgenossische Technische Hochscule, Zurich, Switzerland. He received his master's degree in business administration in 1932, and Ph.D. in economics in 1943 from New York University. After graduation in 1924, he spent two years on water power construction jobs in Michigan, Kentucky, and Tennessee. In 1926, he joined the distribution engineering staff of the New York Edison Company (now a part of the Consolidated Edison Company of New York). During his years with the company, he served in various positions in the transmission and distribution department and the



Courtesy Beverly Studios

Victor Henry Braunig

Volney Judson Cissna



Anatole Rodolph Gruehr

University of Wisconsin

Thomas James Higgins

Russell Marion Kerchner

Clarence Hugo Linder

Lawrence John Lunas

Earl F. Mekelburg

electrical engineering department. In 1948, he was made staff engineer and later senior engineer in the system engineering department. In the latter capacity, Dr. Gruehr was engaged in various economic studies. Among these were rate case studies; comparative economy studies of power plants of several companies; studies of utilization of electric, gas, and steam energy for various purposes; and the problems of allocation and zone rates of the pipe line companies supplying natural gas to the City of New York. Since 1950, Dr. Gruehr has taught in the graduate schools of Polytechnic Institute of Brooklyn and Stevens Institute of Technology. In September of 1950, he retired from the Consolidated Edison Company and undertook his present assignment. Dr. Gruehr is a registered professional engineer in the State of New York. At present, he is a state zone director and a national director of the National Society of Professional Engineers. He served as president of the New York Chapter, 1947-49. For several years he was national chairman of the Engineers' Week Committee. In 1952, he received the Distinguished Service Award of the New York Chapter. Dr. Gruehr is also a member of the American Society for Engineering Education and the Society of Gas Engineers. He has served on the AIEE Public Relations Committee (1955-57).

Thomas James Higgins (AM '40, M '46), professor of electrical engineering, University of Wisconsin, Madison, Wis., has been transferred to the grade of Fellow in the AIEE ". . . for his researches in circuit theory and allied fields and for his leadership in electrical engineering education." Dr. Higgins was born in Charlottesville, Va., July 4, 1911. He received the B.S. degree in E.E. in 1932, the M.S. degree in mathematics in 1937 from Cornell University, and the Ph.D. degree in E.E. in 1941 from Purdue University. Dr. Higgins' teaching experience includes serving as instructor in electrical engineering at Wyomissing Polytechnic Institute, 1935-37; at Purdue University, 1937-41, and as associate professor of electrical engineering at Tulane University, 1941-42. He joined the faculty of the Illinois Institute of Technology in 1942 as associate professor of electrical engineering, becoming professor in 1947. Since 1948, he has been professor of electrical engineering at the University of Wisconsin, teaching graduate courses in electric circuit theory, supervising M.S. and Ph.D. thesis work in this field, supervising undergraduate instruction in basic a-c circuit theory, and carrying out and publishing research in electrical theory. His industrial employment includes experience with Ebasco Services, Inc.; Agfa-Ansco Corp.; City of Ithaca; Associated Gas and Electric Corp.; Wenderly Construction Co.; and Fuller Construction Co. Dr. Higgins is the author of about 120 papers, many of which have appeared in AIEE *Transactions*. He is editor of electrical engineering texts for the Ronald Press Company and has done editorial work for other publishing companies. In 1954, he was selected by the American Society for Engineering Education to receive the George Washington Award for excellence in engineering teaching. Dr. Higgins is a member of the American Mathematical Association, Sigma Xi, and Eta Kappa Nu. He is a registered professional engineer in the States of Illinois and Wisconsin. Currently, he is president of the Southwest Chapter of the Wisconsin Society of Professional Engineers and vice-chairman of the North Midwest Section of the American Society for Engineering Education. He has served the Madison Section of the AIEE in various offices including secretary-treasurer, vice-chairman, and chairman. Dr. Higgins has been a member of the following AIEE Committees: Basic Sciences (1947-57). Feedback Control Systems (1952-57), and Switchgear (1954-56).

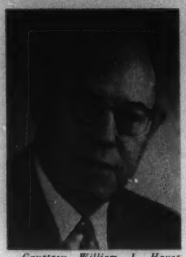
Russell Marion Kerchner (AM '25, M '33), head, department of electrical engineering, Kansas State College, Manhattan, Kan., has been transferred to the grade of Fellow in the AIEE ". . . for distinction as a teacher of electrical engineering and as an author of textbooks in this field." Prof. Kerchner was born in Belleville, Ill., July 29, 1899. He received the B.S. degree in 1922 from the University of Illinois and the M.S. degree in 1927 from Kansas State College. In 1922, he joined the faculty of Kansas State College as an instructor in electrical engineering. He was made assistant professor in 1925, associate professor in 1927, and professor in 1934 in charge of a-c circuits and machinery courses for both undergraduate and graduate work. From 1928 to 1956, he was in charge of the Short Course for Electric Metermen and in charge of the Standards Laboratory. Since 1955, he has been head of the department of electrical engineering, teaching and administering course and research work in electrical engineering. Prof. Kerchner is the coauthor of the textbooks: "Direct-Current Machinery," by Kloeffler, Brenneman, and Kerchner; and "Alternating-Current Circuits," by Kerchner and Corcoran. During his career, Prof. Kerchner has had industrial experience with the Westinghouse Electric Corporation, Sangamo Electric Company, and the General Electric Company. He is a senior member of the Institute of Radio Engineers and a member of the American Society for Engineering Education. Prof. Kerchner is a registered professional engineer in the State of Kansas.

Clarence Hugo Linder (M '54), vice-president, engineering services, General Electric Company, New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions in co-ordinating electrical development and cultivating engineering talent." Mr. Linder was born in Omega, Wis., January 18, 1903. He attended the University of Texas where he received the B.S. degree in E.E. in 1924, and the M.S. degree in E.E. in 1927. He joined the General Electric Company as a student engineer on the company's Test Course in 1924. The early portion of his career included experience as both student and instructor in General Electric's advance courses in engineering. His later assignments included a number of positions concerned with the administrative phase of both engineering and manufacturing operations. These assignments were associated with a wide diversity of the company's products—including consumer goods and heavy apparatus—and embraced a correspondingly wide variety of engineering experience. In 1950, he became manager of engineering and manufacturing for the affiliated manufacturing companies department of General Electric; from there he went to the Major Appliance Division as general manager. On January 1, 1953, the Board of Directors elected Mr. Linder a vice-president. He assumed responsibility for the engineering services function on May 1 of that year. As vice-president, engineering, he is primarily concerned with the establishment and maintenance of the fund of knowledge and understanding needed to insure maximum effectiveness of the engineering function throughout the highly diversified, decentralized businesses of the General Electric Company. Mr. Linder is a member of the American Society of Mechanical Engineers, American Society for Engineering Education, and New York State Society of Professional Engineers. He has received two honorary D.Eng. degrees—from Worcester

Samuel Brooks Morris

Leroy Robards Patterson

Arthur Harrison Phillips



Courtesy William J. Hayes
John Arlington Potts

Polytechnic Institute in 1955, and from Clarkson College of Technology in 1956. Mr. Linder has served on the AIEE Board of Directors (1956-57), and is a member of the Finance Committee (1956-57), and the Planning and Co-ordination Committee (1956-57).

Lawrence John Lunas (AM '27, M '36), engineering manager, instrument department, Westinghouse Electric Corporation, Newark, N. J., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions in the field of design and development of electrical instruments." Mr. Lunas was born in Balfour, N. Dak., September 2, 1905. He received the B.S. degree in E.E. from the University of North Dakota in 1926, the M.S. degree from the University of Pittsburgh in 1939, and the E.E. degree from the University of North Dakota in 1941. Mr. Lunas joined the Westinghouse Electric Corporation in 1926 on the Graduate Student Course. In 1928, he became design engineer in the Instrument Section, meter engineering department. He was made senior design engineer in 1939. On a special assignment during World War II, he was responsible for the development of a new line of switchboard indicating instruments for the U. S. Navy for HI shock application. For this development, he received a Westinghouse special award for outstanding patent. In 1952, he became supervising engineer, and in 1955 he assumed his present position as engineering manager, instrument department. Mr. Lunas is the author of many technical articles and papers several of which have been presented before AIEE meetings. He holds nine patents and is a member of Sigma Xi and Sigma Tau. Mr. Lunas has served as secretary-treasurer, New Jersey Division, New York Section of the AIEE, 1946-47; chairman, 1947-48; and as a member of several Section committees. During the spring of 1948, he delivered a series of 10 lectures on electric instruments and their application as an educational course sponsored by the Power and Industrial Division of the AIEE New York Section. Mr. Lunas has served on the following AIEE Committees: Instruments and Measurements (1938-41), Recording and Controlling Instruments (1956-57), and Indicating and Integrating Instruments (1956-57).

Earl F. Mekelburg (AM '21, M '30, Member for Life), managing engineer, Special Control Section, Square D Company, Milwaukee, Wis., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the design and application of industrial control." Mr. Mekelburg was born in Milwaukee, Wis., February 16, 1900. He took various correspondence and evening courses at the University of Wisconsin. In 1922, he joined the Union Electric Manufacturing Company as chief draftsman. He was made assistant chief engineer in 1924 and chief engineer in 1925. From 1930 to 1932, he was supervisory engineer for Cutler-Hammer Manufacturing Company, purchaser of Union Electric Manufacturing Company. In 1932, he was employed by the Square D Company in the Industrial Controller Division as design engineer. He was made application engineer in 1933, chief application engineer in 1934, and supervisor of the Special Control and Applications Section in 1940. In 1955, he was appointed to his present position of managing engineer, Special Control Section. Mr. Mekelburg has been granted 15 patents for electrical apparatus and circuits since 1927. Several applications are pending. Since 1944, he has served on the General Engineering Committee of the Industrial Control Section of the National Electrical Manufacturers Association as a Square D member or alternate. Mr. Mekelburg is a member of the Engineers' Society of Milwaukee, and an associate member of the Association of Iron and Steel Engineers. He is a registered professional engineer in the State of Wisconsin. Mr. Mekelburg has served on the following AIEE Committees: Industrial Control Devices (1945-57) and General Industry Applications (1946-55).

Samuel Brooks Morris (M '47), consulting engineer, Department of Water and Power, Los Angeles, Calif., has been transferred to the grade of Fellow in the AIEE ". . . for his achievements in engineering education and in the development and operation of a large metropolitan water and power system." Mr. Morris was born in Los Angeles, Calif., August 24, 1890. He received the B.A. degree in civil engineering from Stanford University in 1911, and an honorary LL.D. degree from the University of California in 1953. From 1911 to 1912, he was an engineer with the North Pasadena Land and Water Company. He became assistant engineer of the Water Department of the City of Pasadena, Calif., in 1912. He was made chief engineer of the department in 1913, superintendent in 1921, and general manager in 1925. As general manager, he was responsible for the design and construction of the 328-foot high Morris Dam named in his honor, located in San Gabriel Canyon. In 1935, he became professor of civil engineering and head of the civil engineering department at Stanford University. From 1936 to 1944, he was dean of the School of Engineering at Stanford. During this period, he served as consulting engineer for the Water Department of the City of Pasadena, as well as in other consulting capacities. He was general manager and chief engineer of the Los Angeles Department of Water and Power from 1944 until October 1955 when he retired as active head of the department. At present, he is consulting engineer for the Department of Water and Power in Los Angeles. Mr. Morris has been an active member of the American Society of Civil Engineers, serving as national director, 1953-56. He was president of the American Public Power Association, 1949-50, and a director from 1947 to 1951. He is a member of the National Reclamation Association, the Earthquake Engineering Research Association, American Geophysics Union, American Public Health Association, Seismological Society of America, American Society for Engineering Education and the Newcomen Society of England. In 1950, he was a member of the President's Water Resources Policy Commission. Mr. Morris has been very active in the American Water Works Association. He was president of the California Section of the Association, 1927-28; national director, 1931-33; vice-president, 1942-43; and president, 1943-44. He was awarded the John M. Diven Medal for outstanding service to the Association in 1933. Mr. Morris was a member of the Panel on the Impact of the Peaceful Uses of Atomic Energy appointed by the Joint Congressional Committee on Atomic Energy in 1955-56.

Leroy Robards Patterson (AM '30, M '41), assistant vice-president, electric operations, Public Service Company of Colo., Denver, Colo., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to the planning and development of an electric power system and related interconnections." Mr. Patterson was born in Clarksdale, Miss., September 18, 1901. He attended the Mechanical Engineering School of the University of Arizona and the Electrical Engineering School of the University of Colorado Extension Division. In 1923, he was employed by the Public Service Company of Colorado in the electrical

distribution engineering department. In 1929, he was transferred to the hydro and transmission engineering department. In 1949, he was appointed to the position of superintendent of electric system planning, and in January 1954, he was made assistant vice-president of electric operations. In this capacity, he is responsible for the over-all planning of the development of electric generation, transmission, and distribution to provide for the very rapid increase in load demands, as well as studies and important decisions in connection with contracts and problems relating to the interconnection of the Public Service Company of Colorado with other utilities and the U. S. Bureau of Reclamation. Mr. Patterson has taken a leading and active part in studying and promoting the development of the Upper Colorado River Storage Project of the Federal Government. He is a Public Service Company representative in the Rocky Mountain Nuclear Power Study Group which is studying the future potentialities of power generation by nuclear energy. Mr. Patterson has been active in the work of the Denver Section of the AIEE, and is a past chairman of that Section. He is a registered professional engineer in the State of Colorado. Mr. Patterson has served on the following AIEE Committees: Sections (1948-50), Transfers (1949-52), and System Engineering (1951-56).

Arthur Harrison Phillips (AM '37, M '44), chief electrical engineer, Gilbert Associates, Inc., Reading, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to engineering in the fields of power generation and transmission." Mr. Phillips was born in Reading, Pa., January 3, 1905. He received the E.E. degree in 1927 from Lehigh University. After graduation, he went to the General Electric Company as a test engineer, becoming assistant application engineer in 1929. During 1933, he worked with the Pennsylvania Department of Highways. from 1934 to 1936, he was supervisor of Sewage Disposal Works for the City of Reading, Pa. In 1936, he joined E. M. Gilbert Engineering Company as assistant to electrical engineer. He was made electrical engineer for the Atlantic Utility Service Corporation (successor to E. M. Gilbert Company) in 1941. He was appointed to his present position of chief electrical engineer, Gilbert Associates, Inc. (formerly Atlantic Utility Service Corporation) in 1942. As chief electrical engineer, Mr. Phillips has been responsible for the engineering, design, and application of equipment for transmission and distribution lines and substations, power generation and industrial plants; and consulting services in connection with power system studies and planning. In addition to other projects in the United States, his work has covered several large power generating stations, transmission and distribution lines and substations, and several system studies involving load, frequency, and voltage in Europe, South America, and the Far East. In 1946, Mr. Phillips was instrumental in forming the GAI-Tronics Corp., a subsidiary of Gilbert Associates, and he has been a vice-president since its inception. He is also a member of the Board of Directors of Gilbert Associates. Mr. Phillips is a registered professional engineer in nine states and in Hawaii. He is a member of the National Society of Professional Engineers, Pennsylvania Society of Professional Engineers, Pennsylvania Electric Association, Association of American Railroads, and the Electric Equipment Committee of the Edison Electric Institute. At present, he is serving on the AIEE Subcommittee on Station Design.

John Arlington Potts (AM '25, M '36), assistant vice-president, Wisconsin Electric Power Company, Milwaukee, Wis., has been transferred to the grade of Fellow in the AIEE ". . . for original engineering work and executive direction in a large electric utility." Mr. Potts was born in Chicago, Ill., February 22, 1900. He received the B.S. degree in E.E. in 1923 from the University of Wisconsin. Since graduation, Mr. Potts has been with the Wisconsin Electric Power Company and its corporate predecessor, the Milwaukee Electric Railway & Light Company. He has held the positions of field engineer and service engineer in the Distribution Engineering Division of the electric distribution department; system engineer in charge of the System Engineering Division, electric distribution department; general engineer, executive department; and executive assistant, executive department. He was appointed to his present position as assistant vice-president in 1955. Since 1944, he has been associated with the vice-president in charge of power who is responsible for three large operating departments of the company—electric distribution department, power plant department, and plant engineering department—containing a total of over 2,800 employees. He has had extensive responsibility in the handling of personnel problems and labor relations for all three departments since 1948. Mr. Potts has been an active member of the Engineers' Society of Milwaukee, having served as president, vice-president, director, and chairman of several committees. He is also a member of the Wisconsin Society of Professional Engineers and National Society of Professional Engineers. As a member of the Milwaukee Section of the AIEE, he has served as chairman, secretary, director, and chairman of the Membership and Program Committees.

Haakon I. Romnes (AM '41, M '47), vice-president, operation and engineering department, American Telephone and Telegraph Company (AT&T), New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for his leadership in and contributions to communication engineering." Mr. Romnes was born in Stoughton, Mich., March 2, 1907. He received the B.S. degree in E.E. in 1928 from the University of Wisconsin. After graduation he was employed by the Bell Telephone Laboratories as a member of the technical staff. In 1935, he became an engineer in the Toll Transmission Group of the operation and engineering department of AT&T. He was made head of this group in 1945. Soon after, he became radio engineer and then plant extension engineer of the company. In 1950, he was made chief engineer of the Illinois Bell Telephone Company and, following this, general manager of the long lines department of AT&T. In 1952, he was appointed chief engineer of the company and finally, in October 1955, assumed his present position as vice-president in charge of all operations and engineering for the Bell System. Mr. Romnes is the author of several technical articles and holds six patents. He is a member of Eta Kappa Nu, Tau Beta Pi, Western Society of Engineers, University Club of New York, Academy of Political Science, and a senior member of the Institute of Radio Engineers. Mr. Romnes has served on the following AIEE Committees: Communication (1945-49); Communication Division (1949-56, chairman 1949-51); Technical Program (1949-50, 1951-52); Award of Institute Prizes (1949-50); Planning and Coordination (1949-50, 1955-57); Technical Advisory (1950-51); Safety (1952-55); Lamme Medal (1955-58); Engineers Joint Council alternate (1956-57).

Leon Theodore Rosenberg (AM '30, M '46), chief generator design engineer, steam turbine department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been

Haakon I. Romnes

Leon Theodore Rosenberg

Victor Siegfried

Fred J. Van Zeeland

transferred to the grade of Fellow in the AIEE ". . . for his contributions to the design and development of large steam turbine driven generators." Mr. Rosenberg was born in South Bend, Ind., November 9, 1904. He received the B.S. degree in E.E. from the University of Michigan in 1926 and the M.S. degree in E.E. from the Illinois Institute of Technology in 1949. He has been with Allis-Chalmers Manufacturing Company since 1926 when he joined the company's Graduate Training Course. He was made design engineer, turbine generators, in 1927. From 1942 to 1952, as supervisory engineer, he was head of a group responsible for electrical design and development of all size ranges of turbine generators. Conductor cooling of large machines—supercharged cooling—was developed during this period. In 1952, Mr. Rosenberg became engineer-in-charge, a-c design, and in 1955 he was made engineer-in-charge, turbine generators. He has held his present position as chief generator design engineer, steam turbine department, since 1956. Mr. Rosenberg's professional writings include a number of articles in AIEE *Transactions, Proceedings of the American Power Conference, Allis-Chalmers Electrical Review*, and a paper prepared for the Fifth World Power Conference. He is a member of Eta Kappa Nu, Tau Beta Pi, Sigma Xi, and the Engineers' Society of Milwaukee. He was director of that Society, 1940-43, and treasurer in 1946. He has been an active member of the Milwaukee Section of the AIEE, serving as secretary, 1935-36; chairman, 1939-40, and on the Membership Committee, 1940-42. Mr. Rosenberg is a registered professional engineer in the State of Wisconsin. He has served on the AIEE Membership Committee (1940-42) and Power Generation Committee (1953-57).

Victor Siegfried (AM '32, M '38), chief engineer, The Ansonia Wire & Cable Company, Ashton, R. I., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to the field of dielectrics and cable insulation." Mr. Siegfried was born in Seattle, Wash., December 13, 1909. He received the B.A. degree in 1930 and the E.E. degree in 1932 from Stanford University. He also attended the Graduate School of Engineering at Harvard University. In 1933, he joined the faculty of Worcester Polytechnic Institute as an instructor in electrical engineering and was made assistant professor in 1937. During the summers of 1937 and 1940, he was employed in the high-voltage engineering laboratory of the General Electric Company, Pittsfield, Mass. In 1944, he became chief research engineer of the American Steel & Wire Division, U. S. Steel Electric Cable Works, Worcester, Mass. He joined the Ansonia Wire & Cable Company, Ansonia, Conn., in January 1956 as power cable engineer. In June 1956, he was made chief engineer of the company at Ashton, R. I. Mr. Siegfried is a registered professional engineer in the State of Massachusetts. He is a member of Eta Kappa Nu, Sigma Xi, American Society for Testing Materials, American Society for Engineering Education, and the American Chemical Society. He was chairman of the Worcester Section of the AIEE, 1937-38. Mr. Siegfried has served on the following AIEE Committees: Membership (1940-43); Mining and Metal Industry (1946-55); Industry Division (1948-54); Sections (1947-48); Edison Medal (1948-50, 1951-53); Finance (1948-50); Joint AIEE-Institute of Radio Engineers Co-ordination Committe (1952-54); Publications Committee (1952-55); General Electric Educational Fund Fellowship representative (1955-57); and Dielectrics (1955-56). He was a member of the Board of Directors (1948-54). Mr. Siegfried served as secretary of District No. 1, 1945-46, and vice-president of the District, 1948-50.

Fred J. Van Zeeland (AM '37, M '44), dean, Milwaukee School of Engineering, Milwaukee, Wis., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions as an educator and an administrator in close contact with industrial research." Mr. Van Zeeland was born in Kimberly, Wis., September 30, 1906. He received the B.S. degree in E.E. in 1928 from the Milwaukee School of Engineering. After graduation, he joined the faculty of the Milwaukee School of Engineering as an instructor in electrical engineering. He was appointed chairman of the electrical department in 1933, and director of the College of Engineering in 1945. He became dean of engineering, the position he holds at the present time, in 1951. In addition to administrative responsibilities, he has taught classes in more than 60 subjects, including all undergraduate levels in electrical power and in communications. Mr. Van Zeeland has had experience in industry as well as in the educational field. He has been a consultant for Kurz-Root Company, Chain Belt Company, and Louis Allis Company, all of Milwaukee, Wis. He is a senior member of the Institute of Radio Engineers and a member of the American Society for Engineering Education. As an active member of the Milwaukee Section of AIEE, he has served as secretary-treasurer, director, chairman of the Section, and as a member or chairman of several committees and discussion groups. Mr. Van Zeeland is a registered professional engineer in the State of Wisconsin.

AIEE PERSONALITIES

D. A. Quarles (AM '23, F '41), Secretary of the Air Force, Washington, D. C., has been nominated as Deputy Secretary of Defense. Mr. Quarles, a past president of the AIEE, was born in Van Buren, Ark., July 30, 1894. He was graduated from Yale University in 1916 with a B.A. degree. During World War I, he served for two years in the U. S. Army, being discharged with the rank of captain. In 1919, he joined the Western Electric Company engineering department which, in 1925, became the Bell Telephone Laboratories, Inc. Mr. Quarles became a vice-president of the Laboratories in 1947. He also has served as president of Sandia Corporation and vice-president of Western Electric Company, Inc. He was appointed Assistant Secretary of Defense for Research and Development in September 1953 and assumed the position of Air Force Secretary in August 1955. Mr. Quarles is a member of the American Physical Society, the Institute of Radio Engineers, the Yale Engineering Association, the American Association for the Advancement of Science, and the Telephone Pioneers of America. He has served as a director of the Institute and as a member or chairman of many AIEE Committees.

N. A. Hills (AM '50), electrical design engineer, Moloney Electric Company of Canada Limited, has been appointed assistant chief engineer of the company. Mr. Hills graduated with honors in electrical engineering from the University of Toronto in 1949. He was awarded the H. G. Acres medal and the John Empy scholarship while at the university. In 1954, he obtained his master of commerce degree. He is a member of the Association of Professional Engineers, and the Electric Club of Toronto, and is president of Armour Heights Branch of the Color Photographic Association of Canada.

J. J. Gano (M '52), staff engineer, Digital Computer Laboratory, Massachusetts Institute of Technology (MIT), has announced the formation of J. J. Gano & Associates, Cambridge, Mass., a new consulting service on power systems for electronic equipment, covering the fields of power generation, conversion, distribution and control, and marginal-checking and equipment-cooling systems. Mr. Gano received a B.S. degree in M.E. from Harvard University in 1935 and an M.S. degree in E.E. from MIT in 1952. For the past nine years, he has been a staff member at the Digital Computer and Lincoln Laboratories of MIT where he was responsible for the development of power systems for large-scale digital computers and the Sage air-defense system.

R. J. Freund (AM '46, M '56), chief engineer, Premier Electrical Construction Company, has left this position to become head of the new engineering firm, Robert J. Freund, Consulting Engineers, Chicago, Ill. The firm will specialize in electrical and mechanical design. Mr. Freund attended the Illinois Institute of Technology, receiving the B.S. degree in 1946 and the M.S. degree in 1950. He is a registered professional engineer in the State of Illinois, and a member of the Illinois Society of Professional Engineers and the National Society of Professional Engineers.

R. D. Teasdale (AM '46, M '54), assistant to engineering and development director, Magnetic Metals Company, Camden, N. J., has recently joined the General Electric Company in the missiles and ordnance systems department, Philadelphia, Pa., with responsibility for antenna system design and development. Also, he has recently been appointed chairman of the mathematics department, Evening Division, LaSalle College, in Philadelphia. Dr. Teasdale had been associated with Magnetic Metals Company since 1953, and earlier spent three years as associate professor of electrical engineering at Georgia Institute of Technology in At-

lanta, Ga. He was awarded the B.S. degree from Carnegie Institute of Technology and M.S. and Ph.D. degrees from Illinois Institute of Technology. Dr. Teasdale is a registered professional engineer in the State of New York and is a member of the American Management Association, Institute of Radio Engineers (senior member), Sigma Xi, Tau Beta Pi, Eta Kappa Nu, and the American Association for the Advancement of Science.

C. C. Courtney (AM '53), electrical engineer, Tennessee Valley Authority, Knoxville, Tenn., has been appointed to the staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn., an Atomic Energy Installation operated by Union Carbide Nuclear Company, a division of Union Carbide and Carbon Corporation.

J. T. Wright (M '46), engineer, Carl C. Crane, Inc., Consulting Engineers, Madison, Wis., has been elected vice-president. Mr. Wright, a 1938 graduate electrical engineer of the University of Wisconsin is best known for his activities in the design of rural power distribution systems and telephone systems. At present he is serving as secretary-treasurer of the Madison Section of the AIEE.

OBITUARIES

Andrew Warren Anderson, Jr. (AM '53), partner in the firm of Anderson & Levy, Philadelphia, Pa., manufacturers representatives for electric power equipment, died recently at the age of 34. Born in Philadelphia, Mr. Anderson was a graduate of the Drexel Institute of Technology where he also served as an instructor in the evening engineering school. He had served as district sales engineer for the Clark Controller Company and the General Electric Company. Mr. Anderson was active in the Philadelphia Section of the AIEE and the Pennsylvania Society of Professional Engineers, serving on committees of both organizations.

Eric Brooke (AM '39, M '43), chief engineer, North Electric Company, Galion, Ohio, died recently. Born in Ryde, Isle of Wight, England, Mr. Brooke attended the John Samuel White Marine Technical School in England from 1915 to 1922. He formed his own electrical contracting firm in England before coming to the United States in 1926. His first position in this country was with the Mutual Telephone Company of Erie County, Pa. (now General Telephone Company of Pennsylvania). In 1931, he transferred to Commonwealth Telephone Company of Wisconsin (now General Telephone of Wisconsin) as dial traffic engineer. In 1932, he moved to the Indiana Associated Telephone Corporation (now General Telephone of Indiana) as traffic and commercial superintendent, a position he held until he joined the North Electric Company in 1938. Serving in such capacities as sales engineer, commercial engineer, chief engineer—Telephone Division, planning engineer on president's staff, and assistant director of development, he participated in many new developments by North Electric. Visiting Sweden during the summer of 1954, Mr. Brooke became active in the company's Crossbar Switching System, a project in which he had played a major role during the past three years. Mr. Brooke was a member of the AIEE Committee on Communication Switching Systems (1950-57).

Walter Miner Campbell (AM '28, M '55), Toledo district manager, Bulldog Electric Products Company, Detroit, Mich., died recently at the age of 55. Mr. Campbell, a lifelong resident of Toledo, Ohio, was a graduate of the University of Toledo. He was associated with the Toledo Edison Company from 1923 to 1946, serving as assistant system operator. He had been Toledo district manager of the Bulldog Electric Products Company since 1946. Mr. Campbell was a registered professional engineer in the State of Ohio. He was past chairman of the Toledo Technical Council and was a member of the Electro Club. Mr. Campbell was past chairman of the AIEE Toledo Section, which in 1952 honored him with an award for outstanding service to the engineering profession and to civic progress. He had also served as secretary-treasurer of the Section for 16 years.

Nathan Bert Higgins (AM '19, M '27, F '48), retired, former president of the Safe Harbor Water Power Corporation, died recently at the age of 71. Mr. Higgins was born in Morris Run, Pa. He was graduated from Pennsylvania State College with a B.S. degree in 1909. His early experience included working as a structural draftsman for the Cambria Steel Company and the Penn Bridge Company. In 1910, he was employed by the Baltimore Bridge Company as a structural estimator. Following this, he was associated for several years with the Western Maryland Railway as designer-erector of bridges, buildings, piers, and terminals. He joined the Pennsylvania Water and Power Company in 1914 as chief draftsman in the Baltimore, Md., office. Later he held the positions of assistant chief engineer, chief engineer, and advisory engineer of the company. When the Safe Harbor Water Power Corporation was formed, he was appointed assistant chief engineer. He was promoted to chief engineer and in 1942 was named president of the corporation. Mr. Higgins was a fellow of the American Society of Mechanical Engineers and a member of the Engineers Club of Baltimore and the American Society of Civil Engineers.

Irving E. Moultrop (AM '10, M '12, F '29, Member for Life), retired engineer, died recently. Mr. Moultrop was born in Marlboro, Mass., in 1865. He became an apprentice with the Whitter Machine Company in 1882 and later was made head draftsman. In 1892, he resigned to become chief draftsman of the Edison Electric Illuminating Company of Boston, Mass. He was appointed mechanical engineer in 1897 and assistant superintendent of the construction bureau in 1913. His appointment to chief engineer was made in 1926, and supervision of the construction bureau was added subsequently. He retired from active service in 1935 after 43 years with the company. Throughout his period of service, he had a prominent part in all the construction work of the company, both mechanical and electrical, including transmission and distribution. His achievements were recognized by the award of the Elliot Cresson Medal by the Franklin Institute and the honorary degree of mechanical engineer by Stevens Institute of Technology. Mr. Moultrop was the author of several Institute papers and was past chairman of the Boston Section. He served as an AIEE director, 1926-30, and a vice-president, 1930-32. He had served as a member of several Institute committees including the Power Generation Committee and the Automatic Stations Committee. Mr. Moultrop was a member and past officer of the American Society of Mechanical Engineers and was past president of the Engineers' Club of Boston.

Loyal Ross Milburn (AM '20, M '31, F '39), consulting engineer, Detroit, Mich., died recently. Mr. Milburn was born in Patoka, Ind., March 3, 1894. He was graduated from the University of Michigan in 1918. For 20 years, he served as chief electrical engineer for the Great Lakes Steel Corporation. In 1948, he was sent by the Government to Korea as chief of the Korean Power Mission. He had been sales representative for Hangsterfer's Laboratories, Mantua, N. J., for the past four years. Mr. Milburn was past president of the Association of Iron and Steel Engineers, a member of the Detroit Engineering Society, and an honorary member of the Society for Metal Production of the World. He was a registered professional engineer in the State of Michigan.

David T. Siegel (M '45), president, Ohmite Manufacturing Company, Skokie, Ill., died recently. Mr. Siegel was born in Chicago, Ill., January 11, 1896. He was graduated from Lewis Institute in 1925 with a B.S. degree. He served as a naval officer during World War I. Throughout the rapid growth of the Ohmite Manufacturing Company, which was founded by Mr. Siegel in 1925, he was closely associated with all phases of the business. Mr. Siegel was very interested in the field of education. He was a member of the Board of Trustees of Illinois Institute of Technology and the Armour Research Foundation; he provided scholarships through the National Merit Scholarship Corporation and Scholarship and Guidance Association, provided a graduate fellowship at Illinois Institute of Technology; contributed to the new Hydraulics Laboratory at the Israel Institute of Technology, Haifa. Mr. Siegel was a charter participant in the first nuclear reactor for industrial use at Armour Research Foundation. He was an active planner and major sponsor of the electrical engineering—physics building now under construction at Illinois Institute of Technology and he established the Ohmite Laboratory for Precision Electrical Measurements at Armour Research Foundation. Mr. Siegel was on the Board of Directors of the Illinois Manufacturers' Association and on the National Board of Directors of the American Technion Society. He was a member of the Resistor Industry Advisory Committee under the U. S. Department of Commerce and a member of the Institute of Radio Engineers and Eta Kappa Nu.

Percy Holbrook Thomas (AM '00, M '05, F '12, Member for Life), retired electrical engineer, died recently. Mr. Thomas was born in Boston, Mass., in 1872. He received

the B.S. degree in E.E. from the Massachusetts Institute of Technology in 1893. After graduation, he entered the engineering department of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. In 1903, he became chief engineer of the Cooper-Hewitt Electric Company. In 1907 he established his own consulting engineering offices in New York, N. Y., and continued his private practice until he was appointed consulting electrical engineer to the firm of Guggenheim Brothers in 1916. In 1928 he re-established his own consulting engineering offices, continuing until he was appointed chief of the Power Requirements Division of the National Power Survey, Federal Power Commission (FPC) in 1934. He was with the FPC until his retirement in 1948. Mr. Thomas held a number of patents. He had been engaged in scientific research and had been working on inventions since leaving the FPC. He was a member of the American Society of Mechanical Engineers. Mr. Thomas served on the following AIEE Committees: Electrophysics (1916-17); Meetings and Papers (1914-16, 1924-26); Standards (1914-15); Transmission and Distribution (1914-19, 1924-30, chairman 1914-16, 1924-26); National Joint Committee on Overhead and Underground Line Construction (1914-21); Award of Institute Prizes (1924-26); Lamme Medal (1930-31); and Edison Medal (1931-36).

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of March 21, 1957, recommended the following applications for transfer. Any objections to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Bankus, H. M., application engineer, General Electric Co., Schenectady, N.Y.

Beitch, E., chief engineer, Sachs Electric Co. of Illinois, East St. Louis, Ill.

Blackburn, J. W., chief dispatcher, Central Power & Light Co., Victoria, Tex.

Boon, J. A., project engineer, International Business Machines Corp., Owego, N.Y.

Bradwell, M.I.G., supervisor, network analyzer studies, British Columbia Engineering Co., Ltd., Vancouver, B.C., Canada

Cain, C. H., electrical engineer, Knoxville Utilities Board, Knoxville, Tenn.

Casper, V. O., assistant senior engineer, Socony Mobil Oil Co., New York, N.Y.

Cernik, C. E., electrical engineer, Brown & Root, Inc., Houston, Tex.

Chapman, J. B., chief electrical engineer, Tippets, Abbett, McCarthy, Stratton, Athens, Greece

Clark, C. C., Jr., acting district supt., Southwestern Gas & Electric Co., Marshall, Tex.

Cornell, L. P., Jr., transmission & protection engineer, Pacific Tel. & Tel. Co., San Francisco, Calif.

Coulter, E. L., senior engineer, Westinghouse Electric Corp., Baltimore, Md.

Crites, W. R., application engineer, General Electric Co., Cleveland, Ohio

Dailey, J. J., Jr., control design engineer, Reliance Electrical & Engineering Co., Cleveland, Ohio

Dartnall, R. D., application engineer, General Electric Co., Schenectady, N.Y.

Dowden, V. F., assistant design engineer, The Budd Co., Philadelphia, Pa.

Evirs, H. W., Jr., assistant executive engineer, Fitchburg Gas & Electric, & Affiliated Utilities, Boston, Mass.

Freeman, J. L., electrical engineer, Standard Oil (Indiana), Sugar Creek, Mo.

Garwood, B. J., senior engineer, Atlantic City Electric Co., Atlantic City, N.J.

Govro, M. A., lecturer in electrical engineering, Washington University, St. Louis, Mo.

Graham, R. P., distribution engineer, Eastern Shore Public Service Co., Salisbury, Md.

Hamer, H., senior engineer, Electronic Associates, Inc., Long Branch, N.J.

Hiss, C. A., trunk projects engineer, New Jersey Bell Telephone Co., Newark, N.J.

Holmes, H. T., asst. to genl. supt. of power plants, Arkansas Power & Light Co., Little Rock, Ark.

Holtzinger, J. S., application engineer, Pennsylvania Transformer Co., Canonsburg, Pa.

Horine, J. W., Jr., superintendent, locomotive equipment, The Pennsylvania RR Co., Philadelphia, Pa.

Horton, C. W., district superintendent, Alabama Power Co., Atmore, Ala.

Jenkins, D. R., engineer, Commonwealth Edison Co., Chicago, Ill.

Johnson, S. E., supervising engineer, Commonwealth Edison Co., Dixon, Ill.

Jones, L. W., superintendent, meter & service dept., Kansas City Power & Light Co., Kansas City, Mo.

Joyce, B. C., application engineer, The Bristol Co., Waterbury, Conn.

Kuehn, R. E., senior engineer, International Business Machines Corp., Owego, N.Y.

Kumar, P., managing director, National Electrical Industries, Ltd., Bombay, India.

Lee, A. F., district engineer, Southern Bell Tel. & Tel. Co., Birmingham, Ala.

McElhenny, S. W., development engineer, General Electric Co., Erie, Pa.

Moore, H. D., sales engineer, General Electric Co., Allentown, Pa.

Morton, W. E., electrical specialist engineer, E. I. du Pont de Nemours Co., (Inc.), Newark, Del.

Mueller, E. L., superintendent, system dispatching, Kansas City Power & Light Co., Kansas City, Mo.

Myers, C. S., consulting & application engineer, Westinghouse Electric Corp., Atlanta, Ga.

Okeson, R. H., associate engineer, Light Dept., City of Seattle, Wash.

Perdue, L. P., Jr., distribution engineer, Southwestern Gas & Electric Co., Longview, Tex.

Peterson, A. P., unit engineer, New England Tel. & Tel. Co., Lewiston, Me.

Reed, W. M., district superintendent, Pacific Gas & Electric Co., Chico, Calif.

Reese, S. W., chief engineer, Southern Bell Tel. & Tel. Co., Birmingham, Ala.

Rideout, V. C., professor of electrical engineering, University of Wisconsin, Madison, Wis.

Rivera, E., squad leader, Ebasco Services, Inc., New York, N.Y.

Rowe, A., engineering specialist, General Electric Co., Pittsfield, Mass.

Salmon, F. A., superintendent of meters, Central Power & Light Co., Corpus Christi, Tex.

Sargent, W. S., electrical engineering associate, Dept. of Water & Power, City of Los Angeles, Calif.

Sarwate, V. V., professor, electrical communication engineering, Government Engineering College, Jabalpur, India.

Saslaw, R. L., project engineer, Jack & Heintz, Inc., Cleveland, Ohio

Schachte, W. L., head electronics engineer, Charleston Naval Shipyard, Charleston, S.C.

Shank, R. R., assistant professor of electrical engineering, Yale University, New Haven, Conn.

Shearer, C. W., engineer, Canadian Broadcasting Corp., Montreal, Que., Canada

Siddall, G. P., project engineer, Jack & Heintz, Cleveland, Ohio

Speissegger, H. B., Jr., electrical superintendent, South Carolina Electric & Gas Co., Columbia, S.C.

Stewart, J. D., central district engineer, Southern Bell Tel. & Tel. Co., Birmingham, Ala.

Stoner, T. A., senior engineer, Kearney & Trecker Corp., Milwaukee, Wis.

Street, J. M. Jr., toll transmission engineer, Southern Bell Tel. & Tel. Co., Birmingham, Ala.

Turner, J. A., engineer, Southern Services, Inc., Birmingham, Ala.

Vail, T.F.X., district superintendent, Central Hudson Gas & Electric Corp., Poughkeepsie, N.Y.

Walsh, J. M., administrative engineer, RCA Communications, Inc., New York, N.Y.

Weller, R., distribution materials engineer, General Electric Co., Baltimore, Md.

West, F. P., senior engineer, Consolidated Edison Co. of New York, N.Y.

Zorio, L. F., electrical engineer, U.S. Government, Natick, Mass.

65 to grade of member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member have been received from the following candidates, and any member objecting to election should so notify the Secretary before May 25, 1957, or July 25, 1957, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Bates, H. S., engineer, Iowa-Illinois Gas & Electric Co., Davenport, Iowa

Becken, R. W., construction superintendent, Otter Tail Power Co., Fergus Falls, Minn.

Bongarten, H., manager, General Electric Co., North Bergen, N.J.

Cadillac, D. J., engineering & service supervisor, Westinghouse Electric Corporation, Minneapolis, Minn.

Chadwell, A., manager, Geraldton Area, Ontario Hydro, Geraldton, Ont., Canada

Clark, D. L., engineer, Oak Ridge National Laboratory, Union Carbide Nuclear Co., Oak Ridge, Tenn.

Coleman, J. F., manager, Nodak Rural Electric Co-operative, Inc., Grand Forks, N. Dak.

Dudowicz, J. J., electrical co-ordinator, Tidewater Oil Co., Delaware City, Del.

Eilbeck, A. B., service manager, Nife Incorporated, Copiague, L.I., N.Y.

Gay, M. F., supervisory engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Howard, D. A., Jr., traffic engineer—planning, Southern Bell Tel. & Tel. Co., Atlanta, Ga.

Kempf, V. T., chief electrical engineer, Joseph T. Ryerson & Son, Inc., Chicago, Ill.

Larson, A. P., staff assistant to superintendent of testing, Commonwealth Edison Co., Chicago, Ill.

Lindstrom, T. L., teknologie licentiat, Royal Institute of Technology, Stockholm, Sweden

Linton, J. H., associate engineer, I.B.M., Kingston Military Products Center, Kingston, N.Y.

MacCracken, J. A., engineer, New England Power Service Co., Boston, Mass.

MacRae, D. C., relay engineer, Niagara Mohawk Power Corp., Albany, N.Y.

McDowell, G. R., engineering manager, Westinghouse Electric Corp., Atlanta, Ga.

Morgan, A. J., assistant professor, electrical engineering, University of Dayton, Dayton, Ohio

Moskowitz, L. R., chief development engineer, Erie Mfg. Co., Erie, Pa.

Nickerson, A. D., area radio engineer, Bell Tel. Co. of Canada, Montreal, Que., Canada

Robbins, J. S., manager, Jefferson Davis Electric Co-operative, Inc., Jennings, La.

Roberts, H. C., electrical engineer, Philadelphia Electric Co., Philadelphia, Pa.

Shaw, J. D., transmission engineer, Virginia Electric & Power Co., Richmond, Va.

Sloat, J. E., product development & engineering manager, Cornish Wire Company, Inc., Williamstown, Mass.

Slutz, L. F., supervisory engineer, Westinghouse Electric Corp., Air Arm Div., Baltimore, Md.

Stearns, C. M., senior development engineer, Duquesne Light Co., Pittsburgh, Pa.

Todes, R. S., supervisory engineer, Westinghouse Air Arm Div., Baltimore, Md.

Uiga, E., chief engineer, Ballantine Labs., Inc., Boonton, N.J.

Upton, A., director of European Operations, Federal Pacific Electric Company of Newark, N.J., Chislehurst, Kent, England

Weitekamp, M. E., district manager, The Louis Allis Co., Atlanta, Ga.

Williams, P. H., division plant superintendent, American Tel. & Tel. Co., Cleveland, Ohio

Wittenberger, W. W., chief engineer, The Petersen Oven Co., Franklin Park, Ill.

Young, D. E., superintendent—utilities, U.S. Steel Corp., Columbia-Geneva Steel Division, Provo, Utah

34 to grade of Member

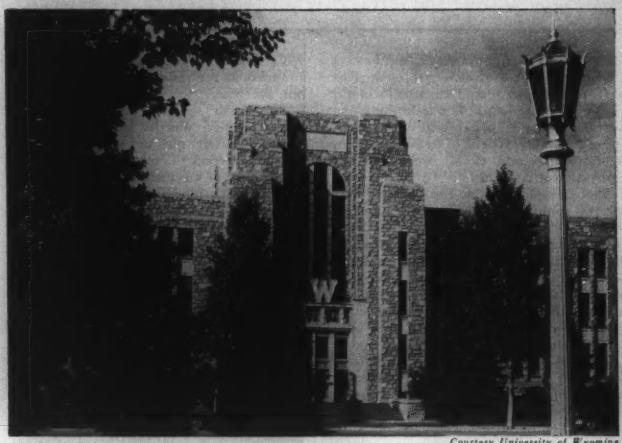
ELECTRICAL ENGINEERING EDUCATION

AIEE in University of Wyoming

THE AIEE STUDENT BRANCH was established at the University of Wyoming on October 14, 1925, with Prof. G. H. Sechrist as counselor. The Joint Student Branch of AIEE-Institute of Radio Engineers (IRE) was established on June 2, 1948. When the Branch was established, there were approximately 30 students in electrical engineering. Prof. Sechrist was the entire staff. At present, there are over 200 students and the staff numbers five. Over the past three years, enrollment has been increasing at the rate of about 30% per year.

The Branch has been active in professional and campus affairs ever since its inception except for a short period during World War II. Early in the fall semester, the Branch attained 100% membership in the senior class.

The counselors for the Joint Student Branch are Prof. R. K. Beach, AIEE counselor, and Prof. E. M. Lonsdale, IRE counselor.



Courtesy University of Wyoming

Alumni of MIT Co-operative Course To Publish Professional Autobiography

WHAT is an electrical engineer? What type of work does he do? What makes him decide to enter the field? These and other questions will be answered for an important segment of the profession in the United States when the alumni of Massachusetts Institute of Technology's (MIT) famed Electrical Engineering Course VI-A publish their collective "co-operative" biography now in preparation.

Engineers who have graduated from Course VI-A since its beginning in 1919 are supplying photographs and biographical data including recollections of youthful experiences and influences motivating their choice of a career. Through a separate anonymous questionnaire, they are contributing salary data, opinions, and evaluations of their educational, professional, and business experiences.

Together with the autobiographical material, the book will include sections devoted to the history of co-operative education in the United States and to the men who made it possible, with a salute to the founders of the graduate co-operative program at MIT. All schools participating in co-operative education will be listed. It is designed not only for the MIT alumni who are contributing information, but also for engineering students and for high school students contemplating careers in engineering. Coming out in the 51st year of co-operative engineering education, and at a time when the entire engineering profession is engaged in various programs of self-analysis and evaluation, this volume should be of great interest to many engineers, employers, and prospective engineers. Also, it is expected to be a useful tool for industry, high schools, libraries, counselors, and educational consultants.

It is believed that this publication will serve as a guide to encourage the alert high school student to slant his studies toward engineering and point a way by which he can achieve his goal. At the same time, the value and need of more graduate co-operative training programs is emphasized. Such programs, when designed to enhance the classroom instruction, increase student motivation and give practical perspective to the ultimate objective of an engineering training. The outstanding record of 1,100 alumni of this program is a living tribute to the creators of this plan.

Heading the committee preparing the book is A. L. Dowden. Faculty advisor is Prof. E. W. Boehne, who is in charge of the VI-A Co-operative Program at MIT. Single copies of the Co-operative Course VI-A Book will be priced at $10. Three copies will be sold at a package price of $25. All requests should be directed to Room 4-207, MIT, 77 Massachusetts Ave., Cambridge 39, Mass.

NOTE: Those graduates of Course VI-A who have not received information concerning this publication please contact the aforementioned office as early as possible.

AIEE Alabama Section Holds Annual "Students Night" Meeting

ON FEBRUARY 11, the AIEE Alabama Section held its annual "Students Night" Meeting in recognition of the Student Branch of AIEE at the University of Alabama, Tuscaloosa, Ala., and Alabama Polytechnic Institute, Auburn, Ala.

The Alabama Section has always strived toward increasing the student's interest in the field of electrical engineering and promoting a closer relationship between the professional engineering field and the student himself. As has been the custom in the past, the electrical engineering students have been requested to prepare and submit technical papers on some phase of electrical engineering. During the meeting, awards were presented for the technical papers selected by the Alabama Section. The first

place award went to the co-authors of "A Cathode Ray Wattmeter," presented by J. D. Bercaw and Joseph DeLorenzo of the University of Alabama. The technical paper winning second place was "Electronic Meter-Reading System," co-authored by R. G. Mapes and C. M. Norton of the University of Alabama.

Also in attendance at the meeting were the two counselors of the student branches: Prof. A. T. Sprague, professor of electrical engineering at the Alabama Polytechnic Institute and Prof. W. F. Gray, professor of electrical engineering at the University of Alabama. In addition, there were approximately 70 other electrical engineering students attending the meeting from both Auburn and Tuscaloosa.

It is also the purpose of the Alabama Section to introduce electrical engineering students to the different phases of industry and to the progress made in engineering fields. Recently, an excursion to the Allis-Chalmers Distribution Transformer Operation at Gadsden was held with an inspection tour of the General Electric Tube Plant at Anniston. On February 11, the students from Auburn were conducted on a tour of the Alabama Power Company's "Early Bird," an electronic computer for measuring the transfer of power, and then were shown through the Southern Bell Telephone Company to see the latest in communication equipment. To further aid in the promotion of the electrical engineering profession, the Alabama Section of AIEE holds joint meetings with the Student Branches at the respective schools throughout the year.

The guest speaker for the Students Night Meeting was R. H. Annin, Southeastern District turbine specialist of the General Electric Company, Atlanta, Ga. The subject of his discourse was "The Modern Steam-Turbine Generator." In his 30-minute, slide presentation, Mr. Annin briefly reviewed the latest developments in generator design in light of today's ever increasing power generation loads. A feature of his talk was a discussion of new types of cooling required on generators up to 320,000 kva.

Mr. Annin is a 1949 graduate of Occidental College with a B.A. degree in physics. He entered the employ of the General Electric Company in that year and has served in his present capacity in Atlanta since 1954.

Pratt Institute Announces Merger of Two Departments

A merger of the departments of Industrial Engineering and Manufacturing Processes of the School of Engineering at Pratt Institute, has been announced by Dean W. E. Wilson. It is expected that the work of the manufacturing processes area will acquire stature comparable with that to which it has grown in industry today. It is now a much more sophisticated field than it was when the mere operation of machine tools was the principal subject of study. "Increased mechanization and the advent of automation," stated Dr. Wilson, "prompt a closer relationship between the technology of the shop and the scientific basis of present-day industrial processes."

He also announced that Prof. Demetrius Zelios will be in charge of the over-all direction of the new department, which will be called the Department of Industrial Engineering, whereas Prof. Otis Benedict will supervise the production-engineering phase of the activity.

AT A RECENT STUDENTS NIGHT held by the Alabama Section, L. B. Murray (*seated, center*), Section chairman, presents awards for student technical papers to (*standing, left to right*) J. D. Bercaw, Joseph DeLorenzo, C. M. Norton, and R. G. Mapes, all of the University of Alabama.

Hughes Announces Plan of Work–Study for Undergraduates

Start of a work—study program for engineering undergraduates, with full payment of college tuition and related expenses for students while they work part time in their chosen fields, has been initiated by Hughes Aircraft Company, Culver City, Calif.

The new program is expected to raise to nearly 950 the number of part-time or full-time employees studying for degrees at company expense in its extensive engineering scholarship program.

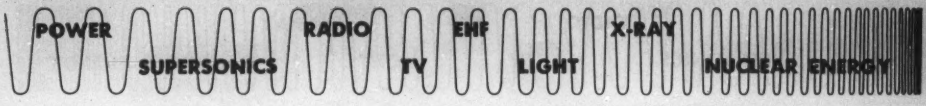
Hughes, largest electronics manufacturer in the West, produces electronic armament control systems used in United States and Canadian all-weather jet interceptors, as well as the Falcon guided missile and commercial products. Under its scholarship program, established in 1953, the company currently has nearly 900 employees studying for bachelor's and master's degrees, plus another 20 studying for doctorates.

The recent announcement extends the program to undergraduates outside the company for the first time.

Co-operating in the new program, called the Hughes Work—Study Program for Undergraduate Engineers, are Loyola University of Los Angeles, the University of Southern California, and the University of California at Los Angeles.

Under the plan, developed by Hughes and university officials, juniors and seniors in electronic, mechanical, and industrial engineering who qualify will work 20 hours a week as student engineers at the company's plant at El Segundo, Calif. Their duties will be tailored to supplement classroom studies, with working hours adjusted to avoid conflict with classes. In addition to pay for their work, students also will receive education grants from Hughes covering their college tuition, laboratory fees, and related expenses.

"No participating student will be obligated to continue his employment at Hughes when he graduates," emphasized



Joseph Ferderber, manager of the El Segundo plant, who made the announcement.

Each work–study student will be permitted to carry from 9 to 13 units of upper division engineering each semester, and 3 to 6 units during each half of the double summer sessions at the three participating universities. Students may spend up to three years in the Hughes program while completing their college studies, it was stated.

Applications are being accepted only in writing and should be addressed to Hughes Aircraft Company, Training Dept., Box 45426, Airport Station, Los Angeles, Calif. Information is also available at the Training Department office at 2060 East Imperial Highway, El Segundo, Calif.

Columbia University Offers Engineering Literature Course

A course in engineering literature will be offered again at Columbia University's School of Library Service during the 1957 Summer Session, July 8-August 16. The instructor will be Russell Shank, engineering and physical sciences librarian of Columbia University. Mr. Shank has degrees in both librarianship and engineering from the University of Washington and a master's degree in business administration from the University of Wisconsin where he served as instructor and acting librarian in the College of Engineering.

The course will consist of a survey and evaluation of library resources in engineering and the physical sciences. The emphasis will be upon bibliographical and information sources, with some attention to special service problems in libraries for engineering and the physical sciences.

Career Guide Issued for Electrical Engineering Students

Careers Incorporated has recently published Monograph No. 2 in The Career Guide Series entitled "Careers for the Electrical Engineer."

The purpose of this booklet is stated in the introduction as follows: "Much has been said about the pressures and excesses of technical recruiting resulting from the tremendous demand for engineers and scientists. This publication is an attempt to re-establish some sanity in the process by giving you, the much sought technical man, information that will help you make an intelligent and informed analysis of the opportunities available."

Included among the editorial features are: a brief description of the AIEE; an article by AIEE President M. S. Coover, "Outlook for Young Electrical Engineers"; a discussion of the electrical engineer in the field of nucleonics by P. N. Ross, chairman of the AIEE Nucleonics Committee; "Research and Electrical Engineering," by M. S. Oldacre (F '47), senior staff consultant on electrical engineering and energy research at Stanford Research Institute; and "Electro-Biology as a Career," by T. H. Rogers, chairman of the AIEE Committee on Electrical Techniques in Medicine and Biology.

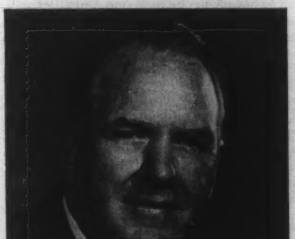
In the second section of the booklet, Employer Presentations, leading national employers highlight their job opportunities for qualified young men.

Special indexes include Leading Employers Directory, Geographic Index, and Special Interest Index.

At the end of the publication is a description of the Career Resume Service operated by Careers Incorporated.

The price of the booklet is $1. For further information, write: Careers Incorporated, 15 W. 45th St., New York 36, N.Y.

An Electrical Engineer in Education



E. B. KURTZ (AM '20, F '29, Member for Life), professor and head of the electrical engineering department, State University of Iowa, Iowa City.

"My 36 years of membership in the AIEE has given me the definite feeling of belonging to a profession. Association with those of my contemporaries who were doing the pioneering in electrical engineering was a privilege. Hearing and talking to such giants as Steinmetz, Lamme, Zworykin, Armstrong, Scott, Sporn, and others gave me many thrills. Furthermore, the opportunity provided to submit and present papers giving the results of my own researches from time to time made me feel that I too belonged to that profession. Instead of feeling that as a teacher I was an outsider, I was convinced that I too belonged. This feeling has been quite similar to that of being a member of a family.

"After serving as a department head for 31 years and observing the careers of several thousand graduates, I am convinced that those students who participated in Student Branch activities are those I hear most about after graduation. Student Branch participation is the beginning of professional life for many a student. In a Branch, students obtain experience as officers and as members of committees. They plan and supervise projects; they invite and hear speakers; they prepare, present, and discuss papers. To many students this is their first experience of being part of a professional unit. To many this becomes the stepping stone to further activity in Sections, District meetings, and Winter and Summer meetings.

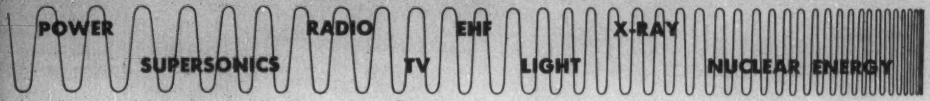
"Next to my daily contacts with students in and out of the classroom, I cherish among my pleasantest memories the fellowship of members of the Institute."

After graduation from the University of Wisconsin in 1917 with the B.S. degree in E.E., Prof. Kurtz entered the General Electric Company (GE) Test Course. While at GE he also attended Union College and earned the M.S. degree in E.E. in 1919. From GE he went to Iowa State College as assistant professor and continued graduate study, receiving the Ph.D. degree in 1932. In 1925, he transferred to the Oklahoma A and M College as professor and head of the department. In 1928-29 he also served as acting dean of the College of Engineering. In 1929, Prof. Kurtz went to the State University of Iowa where he is professor and head of the electrical engineering department at present.

Besides serving as Branch counselor for 31 years, Prof. Kurtz was chairman of the Great Lakes Student Activities Committee in 1935 and 1952, chairman of the Oklahoma Section in 1927, and of the Iowa Section in 1935. He also has been a member of several national committees.

Prof. Kurtz is the author of six engineering books and some 50 technical papers. He served as national president of Eta Kappa Nu in 1952. He also has served as vice-president and president of the North Midwest Section of the American Association for Engineering Education.

Electrical Engineering Education



"Students Night" Is Theme of Philadelphia Section Meeting

"Students Night" was the theme of the February meeting of the Philadelphia Section of the AIEE. Electrical engineering students from the junior classes of the Drexel Institute of Technology, Princeton, Swarthmore, University of Pennsylvania, and Villanova were guests of the Section at a dinner-meeting attended by over 300.

S. Charp, senior staff engineer of the Franklin Institute, spoke on "The Arts and Sciences of Guided Missiles." He traced the development of guided missiles from the earliest rockets of several hundred years ago to those now in operation. Mr. Charp showed slides of current missiles and discussed the types that might be expected in the future. He described the many problems encountered in missile design and control, and the techniques used in solving them.

C. T. Pearce, Westinghouse Electric Corporation, vice-president of AIEE District No. 2, presented Certificates of Award to A. C. Muir, Berwind-White Coal Mining Company, past national director of the AIEE, and the following past national committee chairmen: Dr. S. R. Warren, University of Pennsylvania; J. D. Wood, I-T-E Circuit Breaker Company; R. E. Cordray, General Electric Company; G. W. McKenna and W. E. Scholz, Philadelphia Electric Company.

First Prague Technical School Was Established 250 Years Ago

The first School of Engineering in Prague, Czechoslovakia, was founded by the Emperor Joseph I for C. J. Willenberg on January 18, 1707. At the school, Prof. Willenberg taught geometry and geodetics, including work on the earth's surface as well as underground. His successor in 1726 was Prof. Schor, who taught mathematics, geometry, statics, hydrostatics, aerometry, mechanics, and hydraulics. In 1780, the number of students was raised to 213. Since 1806, the Polytechnic Institute of Prague has been established with a one-year course in chemistry and with a three-year course in mathematics, which incorporated the study of mechanics and constructional engineering. The first director of the Polytechnic Institute was Francis Gerstner, who proposed the first large railway on the continent from Budweis to Linz. Since 1832, the professors at the Polytechnic Institute have been considered equal to university professors.

In 1863, the Polytechnic School was subdivided into four divisions: Constructional for waterways and roads, Building Architecture, Mechanical Engineering, and Technical Chemistry. Electrotechnics as an independent subject was introduced in 1884.

Among the outstanding achievements of the Polytechnic Institute is the work of Prof. K. V. Zenger who developed a theory of the electromagnetic disturbances on the sun, underlying his method of forecasting the weather. His colleague, Prof. Wald, pioneered in the chemistry of phases, and Prof. Adolph Shubrt worked out the history of telecommunications on wires.

Technical subjects have been taught continuously in Prague ever since the first charter for a technical school was granted 250 years ago, in 1707.

University of Wisconsin Offers Engineering Institutes

The following Engineering Institutes will be offered by the University of Wisconsin on the Madison campus.

Industrial Noise Control, May 1-2. This institute will include discussions on what noise is, how it is measured, and the effect of noise on the individual. Ways of reducing or controlling noise in equipment, offices, and working areas also will be discussed. Sessions will be included on legislative and compensation trends in this field. Fee: $20. R. D. Smith, institute co-ordinator.

Industrial Engineers' Seminar on Human Engineering, May 7-8. This seminar will be devoted to discussions of the physiological and psychological nature of the worker. Learning curves, motivation, fatigue, and creativity will be some of the topics discussed. Chief industrial engineers, training specialists, and production supervisors will be interested in this meeting. Fee: $25. R. A. Ratner, institute co-ordinator.

Engineering Photography, May 9-10. Discussion and demonstrations of the latest photographic techniques available to the engineer to help him do his job quickly, easily, and more efficiently will be discussed. Experts from the field will discuss costs and benefits of photography in engineering. The institute will be of interest to engineers in all fields, administrators looking for better methods, and industrial photographers. Fee: $20. L. E. Johnston, institute co-ordinator.

Plastic Laminates, May 13-14. This institute is directed toward the material supplier, molder, or fabricator, and end user of laminates. Subjects to be discussed include fiberglas reinforced plastics, high and low pressure laminates sandwich construction, equipment, and problems in lamination of dissimilar materials. Fee: $20. R. D. Smith, institute co-ordinator.

Water Conditioning, May 15-16. Discussion topics at this meeting will include the water cycle, properties of water, nature of water impurities, water tests and analyses, water treatment methods, nature and identification of deposits, boiler water treatment, boiler scale and corrosion protection, boiler carry-over and embrittlement protection, return line protection, cooling water systems and treatments. Persons responsible for the operation of heating, process, or power equipment will find this program helpful. The rapidly developing application of recirculating cooling waters will receive proper emphasis in this meeting. Fee: $25. P. J. Grogan, institute co-ordinator.

Engineering Organization, May 21-22. Chief engineers, works' managers, managers of research and development departments, and others holding similar positions have the problem of making the best use of the time of the engineers in their department. Current information in three general areas will be stressed: (1) management controls, (2) operating techniques, and (3) understanding of the human relationships involved. Fee: $20. R. A. Ratner, institute co-ordinator.

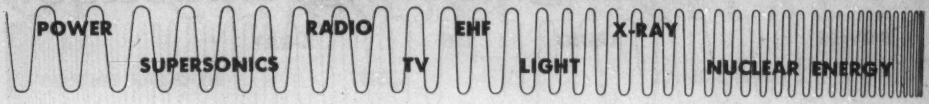
Nominations Requested for University of Toronto Award

At each Triennial Reunion, the Engineering Alumni Association of the University of Toronto presents two medals to two outstanding graduates in engineering. Twelve medals have been given since 1939. To be the recipient of such a medal is an honor which is highly prized and is one of the most coveted awards a graduate can receive.

The award medal is beautifully designed, and has a Greek inscription which is literally translated as "For Achievement." The list of engineering graduates to whom the award has already been given is in itself an honor roll.

The purpose of the award is to recognize the accomplishments of engineers, graduates in applied science of the University of Toronto (Ont., Canada) who in a quiet unobtrusive way have contributed greatly to engineering knowledge, or who through their patient and skillful application of engineering training have been successful in developing methods or machinery for the advancement of Canadian industry, or whose accomplishments have contributed to the comfort, convenience, or welfare of humanity.

The Engineering Alumni Association has appointed a committee, representing the different branches of engineering, to receive nominations for this award. In sending forward a nomination, details of the achievements and merits of the nominee must be given. This would include such information as the year of graduation, the department from which he graduated, any specialized post graduate courses taken, the



special field in which he worked, and particulars of his contributions to the science of engineering and public welfare. This information is essential to the committee in arriving at a fair and just estimate of the merits of each candidate.

The committee is seeking the co-operation of all graduates to find men worthy of this award. Please send the nomination with complete pertinent information before July 1, 1957, to J. D. Barnes, Secretary, Engineering Alumni Medal Committee, c/o Canadian Standards Association, Box 506, Weston, Toronto 15, Ont., Canada.

Nuclear Fellowship Applications Received from 300

Applications have been received from 300 candidates for special fellowships in nuclear technology sponsored by the Atomic Energy Commission (AEC).

The Fellowship Program was established to encourage more students at the graduate level to pursue courses of study in physical sciences and nuclear energy technology with particular emphasis on reactor development. The fellowships are part of the AEC's general program of assistance in the field of education for the purpose of alleviating the shortage of trained nuclear scientists and engineers.

The AEC earlier approved proposals from 28 universities for participaion in the new fellowship program. Additional proposals from other institutions which may wish to participate in the program later will continue to be considered.

About 150 fellowship appointments are expected to be made annually under the program. The selection of candidates for the fellowships will be made by a committee composed of representatives of the AEC, educational institutions, industry, and the Oak Ridge Institute of Nuclear Studies (ORINS) which administers the program for the AEC. The appointment of the candidates will be made for the academic year 1957-58.

The fellowships, awarded for one year of study, carry a basic stipend of $1,800 with additional allowances for dependents, tuition, etc. Information concerning the fellowships may be obtained from: Fellowship Office, Oak Ridge Institute of Nuclear Studies, Post Office Box 117, Oak Ridge, Tenn.

CORRECTION: On page 163 of the February issue of *Electrical Engineering*, it was stated that the Student Branch of the AIEE at Ohio Northern University, Ada, Ohio, founded in 1912, was the first AIEE Student Branch in the State of Ohio. However, it has been brought to our attention that a charter for an AIEE Student Branch was granted previously to the University of Cincinnati, Cincinnati, Ohio, on April 10, 1908.

Technical Personnel Recruiting Exposition Scheduled for Chicago

Aimed at correcting the technical manpower shortage, a Technical Personnel Recruiting Exposition has been scheduled in Chicago, Ill., for five days, June 8 - 12, 1957.

Presented in conjunction with the National Technical Career Conference, this exposition will be held in the Sherman Hotel, featuring exhibits by leading research and manufacturing organizations, to present maximum information to the personnel attending.

This is a never-equalled opportunity for those with degrees in sciences and engineering to choose a new professional responsibility, making maximum use of their abilities.

The exhibitors will offer a wide selection of professional opportunities. More information will be available at this exposition about the job and the company behind it than has ever been given to prospective technical employees.

There will be no charge to the registrants, but those wishing to attend must register in advance. Registration forms and the bulletin "How To Prepare an Effective Work Experience Resume" can be secured by writing the director, M. W. Hinson, c/o Technical Career Conference, 19 South LaSalle St., Chicago 3, Ill.

To provide registrants with a yardstick with which to measure their professional progress, a series of panel discussions will be led by nationally known figures at the conference.

Progress Made Toward New Campus for Israel's Technion

Throughout the world today, there is a new awareness of the significant role that the engineer and the scientist are playing in our lives. In the free world, and behind the totalitarian curtains, government leaders and educators are constantly seeking ways and means to attract young people to the rapidly expanding opportunities that await them in the fields of engineering and applied science. By contrast, Israel has no shortage of talented and determined youths who wish to become trained as engineers and scientists. There is, however, a shortage of adequate facilities and accommodations at its only engineering college, Technion—Israel Institute of Technology, conceived and launched at the turn of the century, which did not begin its formal academic program until 1924. With an enrollment of 300, Technion set out to provide the young men and women of the Jewish community with technical training, ranging from simple mechanics to complex fields in the new sciences of the 20th century.

Technion, while continuing to maintain its high standards of scholarship and research, has been struggling along with inadequate classrooms, research facilities, and other equipment so vital to a modern institution of engineering. Members of the faculty, some of the world's foremost scientists, have been compelled to conduct classes in makeshift accommodations. Nonetheless, Technion has forged ahead scholastically, adding new facilities and departments.

The enrollment at Technion and its affiliated Technical High School is close to 3,000. Four years ago, the Government of Israel deeded a tract of 300 acres on the slopes of Mount Carmel to Technion, as the site of the Institute's new campus. Plans were immediately made for construction of a group of buildings which will house classrooms, laboratories, lecture halls, dormitories, and administrative offices, and where education could be pursued in an atmosphere conducive to higher learning.

In the United States, the American Technion Society, comprising engineers, scientists, and industrialists, has pledged itself to securing half of the sum needed for this construction. New buildings have risen and are in full use, while others are either under construction or still in the blueprint stage. Technion is regarded as the country's catalytic agent, bringing modern science and technology into every aspect of Israel's life.

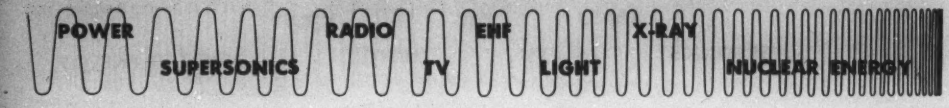
Subcritical Nuclear Unit Is in Use at Georgia Tech

The Georgia Institute of Technology entered into the Atomic Era recently, when Dr. E. W. McDaniel, research associate professor, started a nuclear fission reaction in a subcritical nuclear unit designed and constructed by the Engineering Experiment Station in co-operation with the U.S. Atomic Energy Commission (AEC).

The nuclear assembly consists of an aluminum tank 6½ feet high by 4½ feet in diameter, containing a honeycomb type assembly of 217 uranium-filled aluminum rods immersed in about 83 gallons of water. A controlled chain reaction in the unit is started and sustained by lowering into the tank a neutron source consisting of polonium and beryllium.

The uranium and neutron source material were furnished to Georgia Tech on a loan basis by the AEC together with an outright gift of nuclear detection and research instruments. It is estimated that the cost of the nuclear assembly is about $140,000.

Located temporarily in Georgia Tech's power plant building, the unit eventually will be moved to a new Radioisotopes Building to be constructed on the campus in the near future. In the meantime, it will be utilized as a laboratory instrument for graduate study and research in neutron



and reactor physics as well as supplying radio-active materials for research projects by Georgia Tech faculty and research staff members.

The unit is self-shielding, thereby making it an excellent educational tool. Georgia Tech graduate students will be able to work with the unit at extremely close range without remote handling devices. When the neutron source is removed, the nuclear fission in the unit stops.

Report Issued on Earned Degrees in Engineering

In the Newsletter issued jointly by the Engineering Manpower Commission (EMC) of Engineers Joint Council and the Scientific Manpower Commission (SMC), Washington, D. C., a report was given on earned degrees in engineering. The actual count is over 10% short of the predicted figure. Comparative figures for 1955-56 and 1954-55 follow.

Engineering Degrees

1955-56		1954-55
26,306	B.S.	22,589
4,705	M.S.	4,379
610	Ph.D.	599
1956-57	**Enrollments by Year**	**1955-56**
77,738	1st	72,825
55,767	2nd	50,841
44,610	3rd	39,377
37,571	4th	31,300
1,387	5th regular	1,358
1,838	5th co-operative	1,450
32,210	Other	24,297
251,121	Subtotal	221,448
22,529	M.S. graduate students	18,482
3,402	Ph.D. graduate students	3,163
277,052	Total	243,093

If the number of graduates was lower than anticipated, there is cause for both satisfaction and concern in rising enrollments. Attrition is high, to be sure, as may be seen by comparing the freshman class of 1954-55 with the sophomore class of 1955-56. The Office of Education estimates that only 57% of those who enter engineering courses complete them and obtain the bachelor's degree. Applying the formula to this year's freshman class, graduations may be expected to reach 44,000 in June 1960—if there is no deterioration in the quality of entering students.

The cause for concern lies chiefly in the apparent limitations of educational facilities. Already many schools are reportedly filled to capacity. EMC and American Society for Engineering Education (ASEE) studies in 1956 gave some national form to the rapidly developing engineering faculty problem. Now ASEE, through its Committee on Devolpment of Engineering Faculty will take a broader and more penetrating look at the problem. Meanwhile, EMC will check more carefully the current relationship between engineering school capacity and enrollments. At any rate, the major problem is no longer one of student recruitment but of educational quality all along the line and the provision of adequate facilities and faculty for higher education in engineering and science.

EMC and SMC have made the solution of this problem a major objective. It will be the subject of a National Conference this year sponsored by the two Commissions, the National Academy of Sciences (National Research Council) and the National Science Foundation in collaboration with ASEE and the other societies constituent to EMC and SMC.

ORINS Announces Award of 84 Fellowships

The Oak Ridge Institute of Nuclear Studies (ORINS) has announced the award of 84 one-year fellowships in radiological physics to train a new group of college graduates in the field of study, evaluation, and control of the potential hazards of ionizing radiations. The Institute administers the fellowship program for the U. S. Atomic Energy Commission (AEC).

The selected applicants will begin their formal work under the fellowship this fall; each fellow will spend the nine months of the 1957-58 scholastic year at an assigned university, topping off his academic courses with three months of actual experience at one of three AEC laboratories.

This fellowship program is designed to train college graduates with bachelor's degrees in physics, chemistry, or engineering in the profession of radiological physics—one of the rapidly expanding fields of research resulting from mankind's entry into the atomic age. The new fellows will receive training and experience in radiation physics and biophysics, the interaction of radiation with matter and living systems, dosimetry, electronics, and instrumentation; some understanding of the principles of permissible exposure and the prevention of undesirable exposure; and an introduction to the legal and public relations aspects of radiation protection.

The co-operating institutions in the radiological physics fellowship program are Vanderbilt University and Oak Ridge National Laboratory, the University of Rochester and Brookhaven National Laboratory, and the Universities of Washington and Kansas and the Hanford Atomic Products Operation.

Each fellow will receive an annual stipend of $2,500, additional allowances for a spouse and dependent children, and normal tuition fees, and travel expense.

Erie Resistor Corp. Announces New Educational Training Program

Erie Resistor Corporation, Erie, Pa., announced a new company sponsored educational training program for both technical and business employees. The program was initiated at the beginning of the 1956 fall school semester. It was originally developed by J. D. Heibel, vice-president of engineering and research, and Dr. W. E. Wilson, dean of engineering, Pratt Institute, Brooklyn, N.Y., to fill the needs of personnel in the engineering and research departments. Response within the company has been so great that the program has been expanded to cover all employees.

The new program consists of two major divisions, the "basic training program" and the "individual college educational program."

The basic training phase is designated to acquaint new technical and business employees with the company's organization and product lines.

The aim of the college educational program is to provide guidance and assistance to those interested employees who can qualify for college level courses. The company will reimburse the full cost of tuition to those employees who complete approved courses, with a grade of "C" or better.

For those who wish to obtain advanced degrees, assistance is offered by Erie Resistor in several ways. The Behrend Center of Pennsylvania State University offers a basic graduate study curriculum consisting of 15 credits in advanced mathematics, physics, and engineering mechanics, up to 10 of which can be applied toward "on-campus" requirements leading to M.S. or Ph.D. degrees. Upon completion of such courses, totaling at least 10 credits and providing work assignments can be properly correlated, transfer is arranged to Erie Resistor's plant and laboratories, State College, Pa. Up to 6 hours a week may be used to attend graduate courses at Pennsylvania State University, College Park, Pa., until the advanced degree is obtained. Tuition is paid by the company for courses satisfactorily completed.

In an effort to stimulate interest on a national level, the company has prepared a comprehensive Recruiting Brochure entitled, "This Is Erie Resistor Corporation." Company officials indicate that this book is available to individuals by writing to R. W. Sparks, Supervisor of Placement and Training, Erie Resistor Corporation, Erie, Pa.

OF CURRENT INTEREST

U.S. AIR FORCE supersonic F-102 *new delta-winged jet fighter-interceptor moves smoothly toward the newly installed EFAS Strobeacon system at March Air Force Base, which was formally commissioned recently.*

March AFB and Sylvania Photo

First EFAS Landing Lights on West Coast Installed at Air Base

THE U. S. AIR FORCE recently commissioned a revolutionary approach-lighting system with lightning-like flashes which aid all-weather operation of huge jet bombers at March Air Force Base, of the Strategic Air Command (SAC).

Maj. Gen. A. J. Old, Jr., commander of SAC's 15th Air Force, said that the lighting installation, developed by Sylvania Electric Products Inc., which has been installed and successfully used at New York International Airport (*Electrical Engineering*, March 1956, pp. 302-3), is designed especially for the operation of such aircraft as the eight-jet *B-52* Stratofortress and other high-performance aircraft with increased landing speeds.

Brilliant, fog-piercing lights form the heart of the system known as EFAS (electronic flash approach system). These high intensity center-line lights provide early identification for incoming planes by flashing swiftly in sequence toward the runway from nearly 3,000 feet out.

The SAC flying safety program has actively sought improved runway approach lighting to increase aids needed in all-weather landings, and it is felt that EFAS is a major contribution to that program.

EFAS an Aviation Milestone

The commissioning of EFAS at March Air Force Base (AFB) is a milestone for military aviation, inasmuch as it marks installation of the first flashing approach system at a military base and the first at any airfield—military or civil—in the western United States.

"We consider it a pilot model for the hundreds of Air Force bases throughout the world," General Old declared.

Beams of 30-million candlepower are emitted in sequence twice a second by each of the system's 23 evenly spaced lights. To the crew of a landing bomber, the effect is like that of giant tracer shells traveling at 3,600 miles per hour toward the center of the safe landing area. The significance of this blazing light pattern was pointed out by Brig. Gen. J. D. Caldera, USAF director of flight safety research.

Other than during actual combat, the most critical demand upon a pilot's skill is during transition from instrument to visual flying during low ceiling and restricted visibility. It has been found that where EFAS is operating, visual identification of the landing area is unique and unmistakable.

Breakthrough in Flight Safety

Col. H. J. Fry, flight safety director of the 15th Air Force, called the EFAS development a breakthrough in flight safety research which means fewer unsuccessful approaches by airplanes attempting to land, and less diversion of planes to other bases because of weather conditions. Such problems can be costly because of the high fuel consumption of the newer jets.

EFAS installations have been operating at several civil airports on the East Coast, including New York's International (Idlewild) Airport. They will be "standard equipment" at most major civil airports within a few years and will appear in sharply growing numbers at military installations.

President Eisenhower in his January budget message to Congress has stated that air traffic control must keep pace with the rapidly growing civil and military use of the airways, and recommended funds for the Civil Aeronautics Administration for 1958 to procure and install these airport approach lights.

30 Million Candlepower Flashes

Each of the 23 Strobeacon condenser-discharge lights at March AFB is mounted upon a centerline bar flanked on each side by two white incandescent lamps. Although each Strobeacon emits a flash of 30 million candlepower, the beam is nonblinding inasmuch as it lasts just 1/5,000 of a second.

The centerline "roll guidance" bars inform the pilot of his plane's position in reference to the horizon after the Strobeacons have guided him to where the incandescent lamps are visible. Additional roll guidance is provided for the high performance jet aircraft at points 1,500 feet, 1,000 feet, and 500 feet from the runway threshold by wider horizontal bars extending out from each side of the centerline. Mounted on each of these bars are 20 aviation red incandescent lamps.

One of the spectacular military innovations introduced in the March AFB system is extension of the Strobeacon centerline bars to within 200 feet of the runway. Up to now, this has been barred by an Air Force requirement that the center area be unobstructed for the last 1,000 feet up to the green-lit runway threshold to allow for

March AFB and Sylvania Photo

BRILLIANT fog-penetrating light bursts twice per second in sequence by Strobeacon lamps within the 23 units create an effect like that of giant tracer bullets fired at 3,600 miles per hour toward the March AFB runway. One of the system's Strobeacon units is examined by *(left to right)* R. H. Lindeberg, Sylvania engineer; Col. H. J. Fry, flight safety director of SAC's 15th Air Force, and Maj. Gen. A. J. Old, Jr., commander of the 15th Air Force.

possible emergency landing or take-off situations.

Some Light Bars Below Ground

This problem was solved at March AFB by housing the last eight light bars below ground in concrete grill-covered Elfaka units, supplied by Structural Concrete Products Corp. These rugged units are capable of withstanding the impact of a 200-ton bomber. Seven of these flush centerline bars and a red-lit flush terminating bar are included in the March AFB EFAS installation.

Presence of the flush Strobeacons and bar lights means elimination of the so-called "black-hole" in the previously unlighted area the pilot saw immediately before the runway was reached, which under low visibility conditions, always was an invitation for the pilot to land short.

The flush lights also provide the pilot with the vital depth guidance he requires at that point in his approach. For many reasons, therefore, there is great enthusiasm over the military potential seen in this EFAS installation. Flight safety not only is an integral part of operational efficiency, but also is a contribution to national security.

TACAN Data Link for Efficient Air Traffic Control

GREATER SAFETY through more efficient air traffic control is now possible through the development of a TACAN (tactical air navigation) Automatic Reporting and Data Link System by Federal Telecommunication Laboratories (FTL), a division of International Telephone and Telegraph Corporation (IT&T). The result of six years of research, this newly declassified electronic system represents a major step in bringing air traffic control to a point where it can adequately handle not only the high-speed aircraft now in operation, but also those predicted for the future.

The new system is being made available to aviation authorities at a time when the introduction of supersonic jet aircraft poses new problems in air traffic control. TACAN Data Link can handle the most complex traffic situations with ease, because the exchange of full data on identification, speed, course, altitude, and position for 120 aircraft can take place in only 6 seconds.

TACAN Automatic Reporting and Data Link System, developed for the U.S. Navy, is an additional feature which is being integrated with the commercial VOR (very high frequency omnirange) navigation system. The integrated commercial navigation aid, called VORTAC, will soon become the U.S. Common Air Navigation System.

TACAN Data Link service is provided by merely adding a small "black box" to TACAN or VORTAC equipped aircraft. No new radio equipment is needed.

The instrument panel on TACAN Data Link equipped aircraft contains a number of dual-purpose instruments which simultaneously advise pilots of existing conditions and dispatch orders from the ground station.

For example, the dials give the pilot his bearing and distance from the ground station and, at the same time, the bearing and distance that the air traffic controller has assigned. The same is true for the dials of other instruments, such as the air speed indicator and the altimeter.

Push-Button Messages

Two new panel instruments enable the pilot and ground controller to exchange messages on routine matters through a unique push-button arrangement. Each has at his command a "library" of 31 messages. Should the ground controller want the pilot to let "wheels down," "hold," or "proceed," he pushes the appropriate button and the order appears in word form on the pilot's instrument. Similarly, if the pilot wants to inform the ground station that he is "landing," or "holding," he presses the appropriate button on his instrument panel to convey the information.

One big advantage of the TACAN Automatic Reporting and Data Link System is the elimination of the language difficulty for pilots flying international routes. Some accidents have occurred in the past which were believed to have been caused by the inability of foreign pilots to follow instructions from the tower. With the new TACAN Automatic Reporting and Data Link, the message transmitted from the ground appears in the cockpit as a written message in a small window. The same transmission, therefore, can appear in English in one plane, and in French, German, or Japanese, in other planes.

Air Traffic Control

The phenomenal increase in air traffic in recent years has created a major air traffic control problem because of both the increasing number of airplanes and the extreme speeds at which many of them operate.

Government acceptance of TACAN as part of the common civil and military system—VORTAC—marked a major contribution by IT&T to the solution of the air navigation and traffic control problem. The VORTAC program is now being implemented by the Civil Aeronautics Administration. (TACAN and VORTAC supply information which enables the pilot to know accurately where he is and how to travel on an almost limitless number of airlanes.)

Today's increased air traffic makes control by land-based "air policemen" a necessity. The transmission of accurate navigation information to pilots by automatic means is indispensable. This same information must be made available to air traffic control center personnel, if it is to be of any help in policing air traffic.

Some effort at air control has been made by the use of radar alone. However radar alone, with all its advantages, does not provide a means for accurate and positive

identification of aircraft by the ground personnel responsible for co-ordinating air traffic.

TACAN and the automatic reporting data equipment uses all the techniques of radar but adapts them completely to the needs of identification and automatic reporting of air traffic control.

The new system embodies a scope in which the radar spot is replaced by numbers. The position of these numbers on a map represents the location of an airplane. One number gives its air speed. An arrow passing through the numbers gives the direction in which the aircraft is headed. With this information the ground controller has all he needs for quick decisions. He can work out traffic control instructions, or it can be done in split seconds by electronic computers. The pilot is then given, by means of the TACAN Data Link, a safe course to follow. He merely presses buttons to acknowledge receipt of, and compliance with, these instructions.

Another of the principal problems in the improvement of communications is the short supply of usable frequencies. The TACAN Automatic Reporting and Data Link has the additional advantage of using the regular TACAN frequencies and does not require additional channels which at present are so valuable. The equipment consists of attachments to the TACAN or VORTAC systems, contains no radio circuits, and is applicable to VORTAC as well as TACAN.

Principles of TACAN Data Link

The basic TACAN system contains a synchronizing signal which occurs at a 135-cycle rate. TACAN Data Link System utilizes this same synchronizing signal for the coding and decoding of its information. The surface equipment stops transmission of its standard pulses 45 times a second and inserts a burst of pulses with a special configuration which conveys the entire surface-to-air transmission to a single aircraft. This transmission includes the aircraft's identity, discrete data being transmitted to that aircraft, and all telemetered command information to that aircraft. The duration of this pulse-burst transmission is approximately 3 milliseconds, a relatively short period of time compared with the standard TACAN wave-form patterns. Immediately following the receipt of a message, the particular aircraft addressed transmits back to the surface a similar pulse-burst transmission which conveys its entire reply, consisting of both discrete data and telemetered report data concerning its status.

The Data Link System transmissions, both surface-to-air and air-to-surface, like other TACAN transmissions, employ rounded pulse pairs which are tailored to the narrow TACAN channel spacings. Pulse pairs are employed because of their proved freedom from noise and pulse-type interference. The basic coding techniques are matched to the type of data being transmitted. Because of the basic simplicity of this code, no bulky analog-to-digital or digital-to-analog convertors are required in the aircraft.

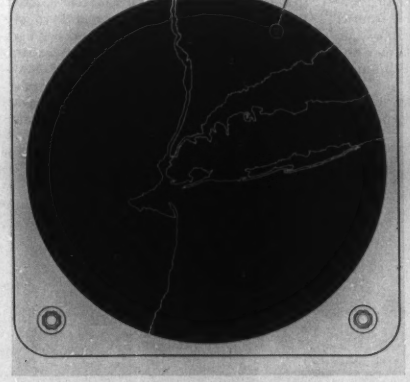
The complete message structure used for the TACAN Data Link System transmission is shown as a single vertical line. The basic TACAN auxiliary north-reference bursts, which are used for synchronizing both the TACAN bearing information and the TACAN Data Link transmission, are followed by various combinations of 35 pulses. These pulses convey the identity of the aircraft, "canned" messages, designation of mode of operation, and various procedural information. Following the transmission of these discrete orders, five pulse-position modulated pulses are transmitted which convey the telemetered control orders to the particular aircraft.

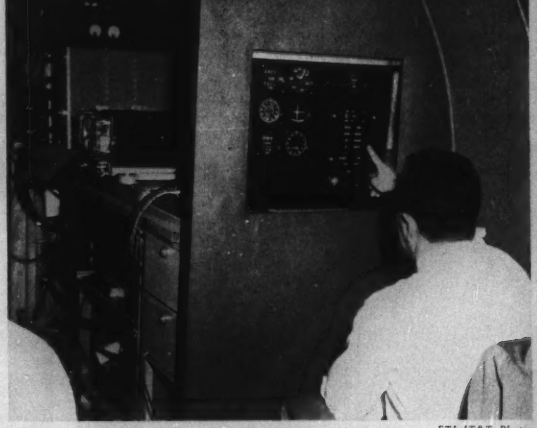
The surface-to-air TACAN Data Link System information is transmitted by means of pulse pairs, just as basic TACAN information is transmitted. The entire pulse train is modulated by the rotating TACAN antenna array. There is no deterioration whatsoever of TACAN bearing information.

Data Link Aircraft Installations

Any aircraft equipment with a TACAN distance and bearing equipment or a VORTAC DME equipment can be provided with a TACAN Data Link System by the addition of the data unit.

Complete two-way Data Link service to the TACAN distance and bearing service con-





FTL-IT&T Photos

FLYING LABORATORY (above) with TACAN Data Link System equipment installed in plane shows operator in front of panel with messages and equipment necessary for complete operation on board an aircraft. Display of air traffic control information (*top right*) gathered by hypothetical TACAN Automatic Reporting Data Link ground station in the New York–New Jersey area. It shows a group of numbers and an arrow at the position of each airplane in the area. The data circled indicates United flight 343 located over Connecticut heading northeast at an altitude of 20,000 feet. A spare character is provided for display of speed, if desired. TACAN airborne equipment and Automatic Reporting Data equipment (*bottom right*) operate all dial instruments and message displays.

sists of a vacuum-tube unit, housed in an ATR rack, weighing 50 pounds and occupying a volume of one cubic foot. The unit contains intrechangeable plug-in units employing vacuum tubes; the type of circuitry used is readily adaptable to transitorization in order to achieve maximum reliability and serviceability.

Data Link Surface Equipment

The TACAN Data Link surface equipment consists of two VORTAC site cabinets and a smaller digital storage cabinet which may be located at the Air Traffic Control Center. The VORTAC site equipment consists of the coding unit and the control unit. The control unit houses the various timing circuits necessary for operation of the equipment, power supplies, and a margin testing and circuit malfunction feature for ease of servicing and providing an output to automatic switch-over equipment. The coding unit accepts data from the storage unit (which may be located at the Air Traffic Control Center). It automatically encodes and transmits orders and, at the same time, decodes reports into suitable form.

A common language digital code has been devised and all orders and reports for aircraft are stored in a digital magnetic drum in that code. Any user of the system may enter orders and receive reports for any aircraft under its control at a time not synchronized with the actual roll-call rate of any particular aircraft.

The military version of the TACAN Data Link System surface equipment, designated the AN/URN-6, is housed in two trailers. One trailer houses a standard TACAN surface installation, and the TACAN Data Link System storage unit, coding unit, and control unit. The second trailer contains control and display equipment designed for the operational evaluation of the TACAN Data Link System by the U.S. Navy. At each of the control positions detailed monitoring of the behavior of a reporting aircraft can be accomplished, and manual orders for precise maneuvers may be introduced.

Paucartambo Hydroelectric Facilities Now Operating in Peru

THE TURBULENT Paucartambo River, which has its source among snow-capped peaks high in the Peruvian Andes, was formally harnessed to the service of Peru's largest nonferrous mining enterprise recently. Representatives of the United States owned Cerro de Pasco Corporation and the Peruvian Government, who were gathered in the eastern Andean foothills, simultaneously threw switches setting in operation Cerro de Pasco's new $25 million Paucartambo 72,000-kva hydroelectric power production and transmission facilities.

More than five years in construction and situated in rugged virgin territory hitherto accessible only by mule and llama trail, Paucartambo represents one of the largest, most remote, and most modern hydroelectric power developments in all South America.

As the first such facility in underdeveloped eastern Peru, Paucartambo is significant for its promise of a new era in Peruvian history when this semitropical frontier region, long isolated by the Andean curtain from Peru's populous coastal area, may find itself the object of widespread colonization and economic development.

The Paucartambo project, begun in 1951, had as its primary purpose the generating of the greatly increased power required to bring Cerro de Pasco's long-range zinc development program to its final stages of completion.

With the additional power now flowing over the 89-mile, 138,000-volt transmission line connecting the new Yaupi Bajo power station with Cerro de Pasco's smelting and refining center at La Oroya, zinc production will be expanded from a current daily rate of 120 tons of slab zinc to 150 tons by the end of 1957. Thereafter, zinc production will be stepped up gradually to an anticipated peak level of 240 tons daily, or approximately 87,000 tons per year.

Altogether, 568 towers of two, three, and five wooden pole construction support Paucartambo's 89-mile transmission line. Because of the rugged terrain, it was necessary in some instances to shoot rope across canyons with a Lyle gun in order to pull poles and transmission cable into position.

A further factor underscores Paucartambo's importance to the Corporation; the new facility effectively doubles Cerro de Pasco's firm power generating capacity, thus providing sufficient additional power for full operation of existing metal refining plants even in years, such as 1956, when rainfall in the central Sierra region was abnormally low.

Speaking at the dedication ceremonies, R. P. Koenig, Cerro de Pasco president, described the project as an outstanding example of an harmonious working partnership involving the Peruvian Government, Cerro de Pasco Corporation, and its 20,000 employees.

Referring to Paucartambo's 65-mile access road, built by Cerro de Pasco at an additional cost of $5 million, Mr. Koenig said that it was the company's symbolic contribution to the highway system of Peru of the new Carhuamayo-Yaupi Highway. What were once fertile terraces of the ancient Incan Empire border many stretches of Paucartambo's new 65-mile access road. Outside the town of Paucartambo, the road passes the remains of an Incan fortress command-

PAUCARTAMBO hydroelectric power development, situated on the eastern slopes of the Peruvian Andes, some 89 miles from La Oroya, became a reality through the construction and maintenance of a 65-mile access road, built at a cost of $5 million. As many as 3,000 workmen were employed in constructing the road, one section of which is shown here. Work crews (inset) erecting a transmission structure on mountainside opposite the access road. Landslides were a frequent danger.

THIS 3,800-FOOT PENSTOCK, with average 7-foot O.D., emerging from Paucartambo's main 8-mile long tunnel at Yaupi Alto, conducts the water to the Yaupi Bajo powerhouse 1,500 feet below. An average down angle of 25 degrees is maintained to the powerhouse level where it branches into three tubes, each supplying water to a single turbine. View of powerhouse (inset) from railway paralleling penstock. Powered by a 250-hp hoist, the inclined railway inches its cars down to Yaupi Bajo at 2.5 mph.

ing the approaches to three valleys inclusive of the broad Paucartambo River valley. Here at the easternmost end of that road, rises the new Paucartambo hydroelectric plant, tangible proof that when human and material resources are joined with modern technology, nature's frontiers can be made to give way in the interest of economic and social betterment.

Participating in these inaugural ceremonies, too, were Carlos Alzamora, Peruvian minister of labor, Victor Ricaldi, senior Cerro de Pasco employee engaged in the project, and the Reverend Prospero Rever, vicar of Cerro de Pasco, one of Peru's oldest Andean mining communities.

The new Paucartambo power plant has an installed capacity of 72,000 kva, or 87,000 hp. The Paucartambo River has been dammed at a site in the Paucartambo Valley known as Yuncan. From this headworks, the water is diverted into an 8-mile tunnel bored through the mountains and is charged down a 3,800-foot steel penstock to the power station at Yaupi Bajo.

The powerhouse, located on the right bank of the Paucartambo 11 miles downstream from the Yuncan dam, houses three generators, each rated 24,000 kva. With the development of a relatively small water storage area, it is possible that a fourth and probably a fifth generating unit may be added to the power plant, increasing its capacity to over 100,000 kva.

Planes and Missiles Tested at 10,000 mph and at 9,000 F

A facility for realistically testing aircraft and missiles in airflow of 10,000 mph and temperatures of 9,000 F for longer periods of time than ever before possible, is being developed for the Air Research and Development Command (ARDC) by the Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.

The Laboratory will build and operate the high temperature test facility under a contract with ARDC's Air Force Office of Scientific Research, Washington, D.C. The large-scale facility will be used to study the materials, structures, and aerodynamic problems of aircraft and missiles flying at hypersonic speeds (five times the speed of sound or greater).

The heart of the Cornell Aeronautical Laboratory test facility will be the "wave superheater," a device conceived and developed by the Laboratory. A pilot model of the wave superheater, developed under a previous contract with ARDC's Air Force Office of Scientific Research, is now in successful operation at the Laboratory.

Essentially, the wave superheater is a unique arrangement of tubes capable of producing a continuous flow of high-speed, high-temperature air. Outstanding feature of its design is the ability to operate at the extreme temperatures well beyond the melting point of all known materials.

The most significant feature of the new research facility will be its ability to operate at the extreme temperatures and speeds of hypersonic flight for periods of 15 seconds or greater. Although test devices producing hypersonic air flow and temperatures are currently in operation at the Cornell Laboratory and other research centers, they can produce the high temperatures and speeds only for brief periods—generally a few thousandths of a second.

These brief test times enable scientists to study certain of the flight characteristics of missile and aircraft shapes in hypersonic flow. The test duration is so short, however, that the materials and structures of the test models are only slightly affected by the extreme temperatures generated.

Actual flight at hypersonic speeds produces temperatures which will melt or wilt conventional metals. With the new facility, Cornell Aeronautical Laboratory and ARDC scientists hope to attack this vital problem by subjecting models to hypersonic air flows and temperatures for long enough periods to permit studying the effect of the extreme temperatures on the model's materials and structures.

The new facility will employ air as the test gas, enabling the Cornell Aeronautical Laboratory to simulate actual flight in the earth's atmosphere.

Patent Granted for R-F Micropotentiometers

A scientist at the Boulder Laboratories of the National Bureau of Standards (NBSBL) has been granted a patent on several related devices that already have been of untold benefit to the electronic industry and defense while the patent was still pending.

The devices, called r-f micropotentiometers, were invented nearly six years ago by M. C. Selby, chief of the NBSBL high frequency electronic standards section, to measure voltages so small that previously they could only roughly be estimated.

During this time, industry and defense have profited greatly from use of the devices. Radio manufacturers, for instance, can now determine quite simply and accurately how sensitive a receiver is. Formerly they could not tell the difference between receivers that had as much as 500% sensitivity difference.

Sensitivity is measured in microvolts which are a millionth part of one volt. The lower the voltage a receiver needs the greater its sensitivity and the better it works, particularly in rural areas or in automobiles.

From a military viewpoint a way of detecting such minute voltage differences has eliminated dangerous guesswork. For example, very accurate determination can now be made of how strong a signal must be generated to beam messages over a certain distance.

Nose Cones for Supersonic Missiles

The main design problems facing missile scientists in their missile research and development work today includes (1) the nose cone, which houses the warhead; (2) the guidance system, which puts the missile on the right path to the target; (3) the airframe, which forms the missile body and contains the various subsystems as well as fuel; (4) the propulsion system, which provides the power to drive the missile into space.

Of these four problems, the first probably

Future Meetings of Other Societies

7th National Materials Handling Exposition, April 29-May 3, Convention Hall, Philadelphia, Pa.

Technorama, student festival and open house, May 1-4, Illinois Institute of Technology, Chicago, Ill.

Pennsylvania Electric Association

Hydraulic Power Committee, May 2-3, Skytop Lodge, Skytop, Pa.

Electrical Equipment Committee, May 9-10, Hotel Roosevelt, Pittsburgh, Pa.

System Planning Committee, May 13-14, Nittany Lion Inn, State College, Pa.

Systems Operation Committee, May 23-24, Skytop Lodge, Skytop, Pa.

4th Annual Conference for Engineers and Architects, May 3, Mershon Auditorium, Ohio State University, Columbus, Ohio

ASHAE, conference and exhibit, May 3-8, Shrine Exposition Hall, Los Angeles, Calif.

Western Air Conditioning Industries Association, Exhibit and Conference, May 4-8, Los Angeles, Calif.

International Home Building Exposition, May 4-12, New York Coliseum, New York, N. Y.

Air-Conditioning and Refrigeration Institute, annual meeting, May 6-8, The Homestead, Hot Springs, Va.

British Industries Fair, May 6-17, Birmingham, England

11th Annual Frequency Control Symposium, U. S. Army Signal Corps Engineering Laboratories sponsored, May 7-9, Berkeley-Carteret Hotel, Asbury Park, N. J.

ISA, Instrumentation and Automation Exhibit, May 9-10, Seattle, Wash.

Institute of Radio Engineers

Professional Group on Microwave Theory and Technique, May 9-10, Western Union Auditorium, New York, N. Y.

National Conference on Aeronautical Electronics, May 13-15, Dayton Biltmore Hotel, Dayton, Ohio

The Electrochemical Society, Inc., symposium, May 12-16, Statler Hotel, Washington, D. C.

Illuminating Engineering Society, technical conference, May 13-14, Pantlind Hotel, Grand Rapids, Mich.

Industrial Nuclear Technology Conference, sponsored by ARF and *Nucleonics* magazine, May 14-16, Museum of Science and Industry, Chicago, Ill.

ASCE, Jet Age Airport Conference, May 15-17, Park-Sheraton Hotel, New York, N. Y.

14th Canadian Regional Conference, IES, May 16-17, Niagara Falls, Ont., Canada

N.Y. State Professional Engineers, Annual Convention and Engineering Industries Exposition, May 16-18, Statler Hotel, New York, N. Y.

AIME, New England Regional Conference, May 17-18, Hotel Statler, Boston, Mass.

ASME

Oil and Gas Power Conference, May 19-23, Kentucky Hotel, Louisville, Ky.

Design Engineering Conference, May 20-23, New York Coliseum, New York, N. Y.

S. A. M. E., 37th Annual Meeting, May 20-21, National Headquarters, Washington, D. C.

NACE, Northeast Region Spring Conference, May 20-22, Syracuse University and Hotel Syracuse, Syracuse, N. Y.

NFPA, Annual Meeting, May 20-24, Hotel Statler, Los Angeles, Calif.

Montreal International Trade Fair, May 20-26, Show Mart, Montreal, Que., Canada

American Society for Quality Control, 11th Annual Convention and Exposition, May 22-24, Masonic Temple, Detroit, Mich.

is the touchiest. When a missile breaks into the atmosphere at speeds in excess of 10,000 miles per hour, forces of heat and pressure are built up. The nose cone is confronted by these forces and is, therefore, subject to disintegration, loss of control, and loss of functional purpose.

A good comparison can be drawn between the nose cone and a meteor. A meteor, when it enters earth's atmosphere, usually disintegrates and falls to the earth as dust. This must not happen to the nose cone. It must remain intact and functional.

The enormity of the task of keeping the nose cone under control and functional presents the crux of the knotty problem. Knowledge in the required fields—aerothermodynamics, aeroballistics, hypersonics, etc. —is relatively meager, yet this knowledge must be extrapolated into unknown technological areas. Consequently, the very frontiers of physics, chemistry, metallurgy, electronics, and other basic sciences must be expanded, and research tools must be developed to enable scientists to work in areas never before explored.

The missile is the Hermes *A-3*, a GE research vehicle developed for U.S. Army Ordnance. Data gathered on the Hermes are being used in designing components and subsystems for missiles under development today.

Hermes, during the flight, was traveling at the relatively slow speed of Mach IV, yet the heat and pressure built up at this speed is sufficient to cause severe heating and partial disintegration. These photographs show that Hermes was still functional upon arrival at the target.

Several hundred top research scientists and engineers are working on the nose cone problem at GE, for, among all the resources used in solving this problem, manpower is perhaps most important. Almost half of the full-time engineers and scientists working for the missile and ordnance systems department have an advanced degree or its equivalent. Over 50% of these people have from 4 to 15 years of missile experience. There runs through this organization the feeling that, when the "race" for the first successful intercontinental ballistic missile is won, the United States is the odds-on favorite.

New Type of Nuclear Reaction Discovered

The observation of a new kind of nuclear reaction that yields energy and is akin to thermonuclear reactions was reported to the American Physical Society (APS) by scientists in the University of California (U of C) Radiation Laboratory.

The discovery was announced simultaneously in Washington, D.C., by the Atomic Energy Commission (AEC), which finances the large program of fundamental research in the laboratory on the Berkeley campus.

The scientists who participated in the research are: Drs. L. W. Alvarez; Hugh Bradner; F. S. Crawford, Jr.; J. A. Crawford; Paul Falk-Vairant; M. L. Good; J. D. Gow; A. H. Rosenfeld; Frank Solmitz; M. L. Stevenson; H. K. Ticho; and R. D. Tripp. Dr. Alvarez presented the scientific paper on the discovery.

The new phenomenon is described as a "catalyzed nuclear reaction." This adds to those reactions already known to science a new and third way of making a nuclear reaction take place. The older ways are either to induce thermonuclear reactions, in which two light nuclei fuse into a heavier one when the temperature is raised to roughly one million degrees, or to bombard nuclei with other nuclear particles from accelerators like cyclotrons or nuclear reactors.

In a normal molecule the nuclei of the component atoms are pulled together weakly by electrons. But the electron can be replaced by a much heavier particle, the negative mu meson. Because the mu is 210 times heavier than an electron, it circles the nucleus at only 1/210th the distance of an electron, and thus binds the two nuclei correspondingly closer. The nuclei then have a good chance of touching, and the nuclear reaction can take place.

The reaction is termed a catalyzed reaction because the mu meson is not consumed by the reaction, but may be ejected from the molecule by the energy released. The mu is then free to catalyze more reactions.

The Berkeley scientists said, however, that at the present time the energy producing reaction is only a laboratory phenomenon. The chain of catalyzed reactions cannot continue long enough to generate commercially useful amounts of power because mu mesons decay into other particles after 0.000002 of a second. Unfortunately, from the point of view of thermonuclear power, mu mesons can be made only in high-energy nuclear collisions of particles accelerated by cyclotrons and other expensive machines. However, the scientists described as "interesting" the possibilities if a much longer lived particle, with properties similar to that of the mu meson, is ever found. The Soviet physicist Alikhanian has reported evidence for such a particle.

Scientists expected that all mu mesons that came to rest in hydrogen would simply decay. Consequently there was excitement in the Berkeley group when it was noticed that occasionally a particle that looked like a mu came to rest, but, instead of decaying, flung out another particle that also looked like a mu, went a short distance, came to rest, and decayed. In some of the photographs, there was a gap between the two mu-like tracks. At first there was speculation about a new particle, a "super-mu" which decayed into an ordinary mu.

Fifteen of these mysterious events were found before the mystery was explained. The pictures are now understood as follows. When the negative mu comes to rest it becomes attached to a proton forming a "mu-mesic atom" similar to an ordinary "electronic" atom, but scaled down two hundredfold in size. In natural hydrogen, one atomic nucleus in 5,000 has a neutron stuck to its proton, and is called a deuteron. It can be shown that a mu meson prefers to form an atom with a heavy particle at its center; so the mu will form an atom selectively with a deuteron, even though the protons are much more abundant. Any mu-mesic atom will eventually attach itself to another atom to form a molecule.

The gaps are explained as a drift of the tiny neutral mu-mesic deuteron atom as it dashes away from the proton from which it stole its mu meson. Any complete atom, regardless of its size, is a neutral system, and does not make a track. Being neutral, the mesic atom makes no track.

The result of all these processes is that shortly after a mu comes to rest in hydrogen it finds itself holding a deuteron and proton together in the form of a tiny molecule. The deuteron and the proton are bound so closely that soon they fuse to form helium-3. The mass of helium-3 is less than the combined mass of a proton and a deuteron and the difference—5.4 million electron volts—is available as energy. This energy of fusion is the same energy that is released by the sun or during thermonuclear reactions.

In order to test their hypothesis, the physicists added artificially concentrated deuterium to the naturally occurring deuterium already in the bubble chamber. As expected, there was an increase in the fraction of photographs in which there was an ejected mu or a gap at the end of a mu. Two pictures out of 10,000 showed a "chain" reaction two links long—where a single mu catalyzed two nuclear reactions before decaying.

After the experiments were completed, a colleague pointed out that in the 1954 Proceedings of the Academy of Sciences of the USSR a theoretical physicist, Ya. B. Zel'dovitch, had already predicted a similar, though somewhat simpler reaction.

The term "catalyzed nuclear reaction" was selected because of the comparison with what happens in chemistry, where a catalyst is used to speed up a reaction but is not itself used up in the reaction. A catalyzed nuclear reaction is similar to a thermonuclear reaction in that the same nuclear fusion reactions are common to both, but the conditions of the surroundings are quite different.

AEC Civilian Reactor Generates Electricity

The Experimental Boiling Water Reactor (EBWR) located at the Atomic Energy Commission's (AEC) Argonne National Laboratory, Lemont, Ill., generated electric power at its full design rating of 5,000 kw for the first time on December 29, 1956, in a test run.

This facility is the first to generate electricity from nuclear energy out of five reactor projects initiated in 1954 under the AEC Civilian Power Reactor Development Program.

Rated at 20,000 kw of heat and 5,000 kw of electricity, this experimental plant has been undergoing initial testing since construction was completed. Other significant events which occurred earlier were the achievement of "criticality," and the first generation of some electricity on December 23, 1956.

The unique feature of this "boiling water reactor" is that live steam actually is generated in the uranium core of the reactor by nuclear heat and is piped directly to a turbine. This concept eliminates the need for the intermediate heat-exchangers required in other types of reactors.

The conceptual design of the reactor was developed by the Laboratory which is operated for the AEC by the University of Chicago. The Laboratory designed and fabricated the reactor core and provided technical supervision for the project.

Projection System Provides Wall-Size TV Pictures

Development of a new portable television projection system which throws large, brilliant pictures on a wall-sized screen has been announced by General Precision Laboratory Incorporated (GPL), Pleasantville, N.Y. It is suitable for easy viewing of either closed-circuit or broadcast television programs of special events by groups of 100 or more.

The new model *PB-611A* incorporates a newly designed optical system which provides sharp, clear picture detail and greatly increases light output over earlier designs. Bright television pictures can be projected on any size screen suitable for the premises from 6 feet wide to 16 feet wide or even more. The *PB-611A*'s pictures are approximately four times as bright as those of the earlier GPL portable systems which were used in such nation-wide closed-circuit television events as the General Motors' 50 millionth car celebration and the "Salute to Eisenhower" dinners.

The superior picture clarity and brightness is due to a new reflector and an advanced corrector plate design. The projection barrel uses optical elements 12 inches in diameter providing an aperture of 0.6. It is believed to be the largest aperture that has ever been achieved with good resolution in a system of this type. The optical system has also been redesigned to simplify adjustment. A new tube support provides easier and more accurate alignment and focusing of the projection tube. Positioning of the tube in any of the three axes without interaction with the others is possible with the new support.

In addition, the *PB-611A* has been designed with the capacity to handle theater requirements for closed-circuit televised events which in the past have included championship fights.

Hard Thinking "Brain" Solves Complicated Problems

Scientists, working with a giant new "electronic brain," have come up with some new wrinkles in the way of improving the device's ability to solve complicated problems.

The Palo Alto Research Laboratory of the Lockheed Missile Systems Division, Lockheed Aircraft Corporation has received the world's first model of the Univac Scientific *1103A*, and its mathematicians have already devised some important programming short-cuts.

Although the huge new machine still needs a programmer—the man who must, through punching buttons, put the computer in the right frame of mind to receive and understand the problem—his work has been considerably simplified by Lockheed.

Two new systems, unglamourously dubbed MISHAP and FAP, are sets of general instructions fed into the machine and stored in its "memory."

With MISHAP (missiles high speed assembly program) so stored, the operator may feed the computer instructions using familiar alphabetic and decimal characters instead of the binary language usually necessary.

Also, under the MISHAP system the computer automatically assigns storage space in its "memory" to the various bits of information being programmed.

The FAP (floating arithmetic package) when "memorized" by the computer allows the programmer to use certain computing "skills" not built into the machine.

The main "skills" are:

1. Floating point arithmetic—which allows the computer to multiply and divide numbers which are very different in magnitude without having to scale them to a common size.

2. Standard transcendental subroutines—or commonly used equations.

3. Input and output on punched cards or magnetic tape.

4. Diagnostic routines—having the computer indicate the flow of a problem within itself and having it indicate contents of selected portions of its internal storage or "memory."

The computing system primarily uses magnetic tape for input and output of information, which the Lockheed experts say is an entirely new technique in the field and is expected to result in much faster computations.

Cosmic Ray Neutrons To Be Counted

New York University (NYU) scientists recently left for Guam where they will work with giant Skyhook balloons, hoping to find, among other things, a new scientific check for the measurement of historic time.

Physicists R. C. Haymes and Harold Blum of the Research Division at NYU's College of Engineering will attach to the balloons the lightest instruments to date for counting cosmic ray neutrons. (A neutron is a part of an atom that carries no electrical charge.) For three weeks, the U. S. Navy will fly the balloons to heights of more than 100,000 feet.

The Guam project will complete NYU's world-wide "census" of neutrons produced in the earth's atmosphere by cosmic rays. (Cosmic rays are streams of invisible high-energy particles that bombard the earth daily from outer space.) The census, directed by Prof. Serge Korff, was begun 10 years ago. It has included observations at the Equator, in the Caribbean, at the North Geomagnetic Pole, and at several points in the United States.

Weather and schedules permitting, the NYU group also will send a balloon aloft at night to test for the first time a new theory that primary cosmic ray neutrons are reaching the earth from the sun.

Radiocarbon dating is the method by which the total "population" of cosmic ray neutrons determined by physicists will help archaeologists date accurately such fossils as ancient human skeletons and the remains of prehistoric trees.

Archaeologists, knowing how much of the isotope carbon-14 a plant or animal absorbs while it is alive, and knowing also the rate at which carbon-14 decays, now measure the amount in the fossil at the time of its discovery and work backwards to determine its age. Carbon-14 is produced by cosmic ray neutrons. If scientists knew the total number of cosmic ray neutrons produced each second (the figure being sought), they would know how fast carbon-14 is produced. The use of this rate in their calculations would give them a highly accurate, independent check on the present method and, thus, would be an important tool for archaeological research.

Research by NYU physicists, to date, puts the rate of neutron production at about one per square centimeter (about half the area of a dime) of air per second at the earth's surface—or six *billion* billion each second over the entire earth. The rate of production is 100 times as high at an altitude of 60,000 feet as it is at sea level, since most cosmic rays are blocked by the atmosphere close to earth.

The NYU research physicist group has devised a new type of neutron-counting instrument to be placed aboard the balloons, one using transistors rather than vacuum tubes. The new instrument weighs 28 pounds as compared to 100 for the older one, and—according to Dr. Korff—it is also more reliable. Each of its two counting tubes is one foot long and two inches in diameter. These tubes are filled with a gas (boron trifluoride) that detects neutrons. The results are radioed continuously to the ground by a radiosonde (small transmission set).

In addition, the NYU research group has "souped up" an Army Rawin radio receiver. The original receiver could track a balloon for 125 miles. This one follows it for a much greater distance, as much as three times as far, receiving radio signals of pressure, temperature, and neutron intensity. Because it operates at ultrahigh frequencies, it is undisturbed by atmospheric conditions.

The neutrons on which cosmic ray research has concentrated to date are secondary neutrons, so called because they are produced when a primary cosmic ray strikes a nucleus "target" high in the earth's atmosphere.

Not until Cornell University physicist H. A. Bethe calculated that the "half-life" of a neutron is 13 minutes was there reason to believe that neutrons from the sun could reach the earth's sea level. ("Half-life" is the time it takes for a group of particles to decay to half its original number. Thus, after 13 minutes a neutron beam has half of its original intensity, after 26 minutes, one-fourth, and so on.) It takes eight minutes for a neutron to reach the earth's atmosphere from the sun.

Modern Method for Engineer Placement

To provide positions meeting the exact requirements of engineers, a new plan has been developed by Mechaneers Incorporated, Westport, Conn., called "Trialhire."

Employee Advantages. The Trialhire plan offers a definite path of permanent advancement if the person knows what he wants—knowing is a must. The way that Trialhire works is that first one fills out a form called "Experience and Potential Data Sheet" on which special emphasis is placed on all

qualifications the future position should have to satisfy fully the applying individual. It should specify (1) location, (2) amount of supervision and responsibility, (3) earnings, (4) type of industry, (5) type of duties wanted and capably carried out, (6) thoughts on why one feels able to fulfill requirements of the position, and (7) outline of ultimate aims and ambitions of the individual careerwise and educationwise. The initial interview is made with one of the organization executives of Mechaneers, either evenings or weekends, for a long and thorough interview. Only then, if it is felt that the person is capable of handling a better position, will an arrangement be made for an interview with top management of a client firm which requires a position filled by one with the qualifications and desires outlined by the employee. When both parties are satisfied and wish to give the position a try, the individual enters the firm but is placed on Mechaneers Inc. payroll. Following this, one of three things happens: (1) the position is the one sought, and the client firm as well as the individual feel the right person has the job, and the person is placed on the client payroll; (2) the person feels the position is exactly what is wanted, but the client firm is of a different opinion which indicates that Mechaneers needs to reappraise and place the individual elsewhere and pays a salary until placed (unless the cause for client refusal of individual was for action deemed normal cause for dismissal, i.e., impertinence, falsification on application, incompetence, drunkenness, continual absenteeism, etc.), or (3) the individual decides that the position is not what was expected although client firm feels the individual is the person they want in the position. Mechaneers attempts to rectify the difference and will reschedule the person to another firm if the individual is still dissatisfied after the second trial period, continuing on Mechaneers payroll.

Employer Advantages. Top men are placed working on client firm premises on a trial basis during which time both become acquainted and can make permanent arrangements based on an intelligent appraisal by each. If a mutually satisfactory agreement is not reached, there is no obligation to continue. The men placed by Mechaneers are aggressive, competent, technical men seeking permanent connections at the uppermost limit of their ability. The client firm thus saves in the long run because it has no advertising expense, no agency fees, and no engineering company floaters. Trialhire cuts down on personnel turnover, avoids mistakes, eliminates loss of time and money, and improves caliber of the engineering departments.

Thus, Mechaneers Inc. provides an honorable way of performing top quality temporary technical services and permits the giving of satisfactory value despite unusual conditions prevalent in the present economy.

Descriptive literature is available to individuals as well as firms interested in this Trialhire plan.

Panel-Board Furnace Charging Control System

After more than three years of experiments, engineers of Cutler-Hammer, Inc., Milwaukee, Wis., and Arthur G. McKee & Co., Cleveland, Ohio, have designed a panel-board control system said to be a substantial improvement over present furnace charging control systems.

Basically, the new system consist of three panel boards containing hundreds of circuits and switches keyed to individual lights which automatically control all the processes from the time iron ore, limestone, and coke are taken out of the respective bins until the material is dumped directly into the furnace.

The intermediate steps controlled by the system include the measuring of the component ingredients, the conveying of material on a skip hoist to the top of the furnace, discharging it into a small bell, revolving it in a distributor, and discharging it into a larger bell immediately prior to dropping it into the blast furnace.

Prior to 1940, Arthur G. McKee & Co. in conjunction with Cutler-Hammer, Inc., had designed and were marketing a blast furnace distributor control.

The new system has not changed the basic functions of the control process but represents several substantial improvements over present systems. Included are a more simplified operation of the panel board substantially reducing the training period of operators, and an operational check system which automatically and instantaneously indicates and isolates any failure in the sequence operations of blast furnace charging.

PANEL-BOARD control system for automatically charging a blast furnace shows scale car operator's panel (*left*) behind which are the scale car indicator, manual, and transfer panels. Also shown are the program selector and indication panels (*right*) and the hoist house annunciator panel.

Insulation-Thick Homes Reduce Construction and Operating Costs

Home-builders can construct air-conditioned houses at less cost by using considerably more than the minimum amount of insulation required by the Federal Housing Administration (FHA).

Thick mineral wool insulation enables owners of air-conditioned houses to save substantially on annual heating-cooling operating costs. In southern states, this savings averages as much as 57% of the cost of added insulation installed.

Those are the main conclusions reached in a research study made by J. R. Watt, associate professor of mechanical engineering at the University of Texas. He took data from eight "Air Conditioned Village" houses that were well insulated and compared figures on construction cost, fuel consumption, and operating costs for the houses as built with what these figures would have been if the houses had been insulated in accordance with current FHA minimum requirements.

Professor Watt, who was chief analyst of the Village during its 18 months of operation, found that the builders saved an average of $139.60 in construction cost. Although adequately thick mineral wool insulation was an added expense, it lowered the heat gains of all eight houses sufficiently to permit the use of smaller and less expensive cooling equipment. In every case except one, the net result to the builder was a savings. The greatest net savings was $511.17. The one exception resulted in a net added cost of $19.60.

Professor Watt said, "Each dollar spent on adequate insulation for air conditioning above current minimum property requirements (MPR) saves $1.82 in otherwise required equipment, an 82¢ net saving. This . . . should reduce mortgage requirements."

The average annual operating cost savings was $107.90, computed at "country-wide average" rates of 10 cents an effective therm of gas, 2¢ a kw-hr for electricity, and 25¢ per 1,000 gallons for water.

Professor Watt explained that at Austin's winter design temperature of 10 F, the FHA's current MPR permit house walls to have a heat transfer coefficient ("U" value) up to 0.05 and ceilings up to 0.15.

His conclusion on this point is that "if FHA minimum allowable heat transfer coefficients for residences were to be in-

creased, the result would both increase equipment costs above construction savings and disproportionately raise the homeowner's operating costs."

Professor Watt estimated savings for different regions of the United States. These estimates are:

North and Central States

1. In homes equipped with all-year heating–cooling systems approximating two-ton capacity, planned use of adequate insulation saves as much as, or more than, its own installed value in equipment cost.
2. Where the cooling load in an insulated residence exceeds three tons, the use of extra insulation can save well over its installed value by making three-ton equipment permissible in place of nonstandard four-ton or even five-ton units.

South and Southwest States

1. In homes equipped with all-year heating–cooling systems approximating two-ton capacity, insulation used above FHA current requirements saves in equipment costs up to 1.78 times its own installed value.
2. Where the cooling load in an insulated residence exceeds three tons, use of extra insulation can save up to 3.05 times its installed value by making three-ton equipment permissible in place of nonstandard four-ton or even five-ton units.

The eight houses selected by Professor Watt were insulated entirely with mineral wool. Wall thicknesses were either 2 or 3 inches. Ceiling thicknesses varied from 4 inches to 6½ inches. The most thickly insulated house had 3 inches of mineral wool in the walls and 6½ inches in the ceiling. In it, the net savings to the builder was the highest of all, $511.17. Annual operating savings came to $82.26 at Austin rates, above the average.

Cryotron To Replace Transistors and Tubes

With pioneering research on a new device to replace transistors and tubes in giant computers, the Massachusetts Institute of Technology (MIT) has made a major contribution to what one of its engineers calls a coming "revolution" in electronics.

The new device is a cryotron, so small that 100 will fit into a thimble. It is the first useful application of a phenomenon discovered nearly 50 years ago but still not yet understood.

Development of the cryotron was begun three years ago by D. A. Buck, a graduate student and instructor in the electrical engineering department at MIT, in co-operation with the Lincoln Laboratory.

The first data-processing equipment in which this simple, tiny device will replace complex tubes and expensive transistors is now being built at Arthur D. Little, Inc., with the co-operation of MIT engineers.

This first cryotron electronic catalog will use 215,000 cryotrons. A conventional computer to do the same job might require more than 50,000 vacuum tubes.

The cryotron is man's first practical use of superconductivity—the ability of some metals to conduct current with no resistance at extremely low temperatures, below −420 F. In its simplest form, the cryotron consists of a straight piece of wire with another wire—as fine as a human hair—wound around it as a control winding.

Cryotrons operate only at this extremely low temperature; they must be held at that temperature by liquified helium, whose boiling point it 4.2 F above absolute zero. One part of any cryotron computer will be a special refrigerator, known as a cryostat, to liquefy helium and generate these extremely low temperatures.

A much more important characteristic is basic simplicity. Cryotrons—single wires with tiny coils wrapped around them—can be made by automatic factories at great speed. And they can be made and pre-assembled in long chains, so that circuits formerly requiring many hours for assembly may became routine manufacturing operations.

The number of circuits required for such applications as language translation, for instance, is so great that computers of conventional types seem now to be prohibitive in size and cost.

Another cryotron advantage is its small use of electric power: because resistance is negligible in superconductive circuits, the electric currents flow with little power loss.

One of its disadvantages at present is its slow speed. Even though a cryotron can switch from one condition to another as rapidly as a transistor or vacuum tube, the cryotron circuits switch electric currents among their countless paths relatively slowly.

Experimental Reactor Started Up and Shut Down 10,000 Times

The first atomic reactor ever operated in the northeastern United States has been started up and shut down a record 10,000 times for experimental purposes, a General Electric (GE) Company scientist reported recently.

Dr. H. B. Stewart of the Knolls Atomic Power Laboratory (KAPL) staff, said that the Preliminary Pile Assembly (PPA) at KAPL also "is believed to have produced more information about a larger variety of reactors than any other assembly." PPA has been operated successfully for 8½ years.

Several completely different types of reactor designs have been simulated in the pioneer assembly, constructed by GE scientists and engineers for the solution of nuclear physics problems likely to be encountered in later reactor construction.

KAPL is operated by GE for the Atomic Energy Commission (AEC).

Scientists and engineers there have designed and constructed reactions for the prototype power plant for the submarine *Seawolf* and the actual *Seawolf* power plant. Currently, they are designing the submarine advance reactor for use in the world's largest submarine, the *Triton*, now under construction.

PPA, which can be shut down and restarted in 15 minutes to facilitate rearrangement of fuel elements, has simulated the performance of a large variety of reactors, Dr. Stewart reported.

This has been accomplished through relatively simple design modifications of the fuel elements in one or both of the hexagonal reactor tube bundles, Dr. Stewart explained.

The reactor is said to work as follows:

On the basis of calculations or previous experiments, an appropriate number of uranium-aluminum fuel discs are loaded into fuel rod subassemblies which are then inserted into the two vertical faces of the reactor tube bundles. In addition to the fuel discs, the fuel rods contain discs of other materials which simulate the structural materials, coolant and moderator which are proposed in the reactor design. For ease of handling, these discs are held together by tie rods which extend through central holes in the discs.

When the fuel rods have been loaded into the proper geometric pattern, the two halves are moved together by remote controls which are located in a separate room behind a four-foot thick concrete wall. After the halves have been brought together, control rods are moved into positions which cause the reactor to become chain-reacting.

Quick access to the reactor cell following an experiment and changeover of fuel elements are possible since the PPA is operated at only about 1 watt, which limits the induced radioactivity to a minimum value.

The design of the PPA, which is one of five experimental reactors in use at KAPL, was originally conceived and built by Dr. T. M. Snyder and a group of scientists at KAPL in 1948.

Date Set for Technical Writers' Institute

The fifth annual Technical Writers' Institute will be held at Rensselaer Polytechnic Institute, Troy, N.Y., beginning Monday, June 10, and running through Friday, June 14. Planned throughout as an aid to the technical writing profession in industry, the general program will be in charge of J. R. Gould, director.

The over-all workshop includes sessions on manuals and instruction books, reports, technical promotion, training programs, industrial films, graphic and illustrative aids.

Additional information on the next session of the Institute can be obtained by writing J. R. Gould, Director, Technical Writers' Institute, Rensselaer Polytechnic Institute, Troy, N.Y.

Solar Furnaces as Research Instruments

Solar energy, focused to an intense heat in a man-made solar furnace, has become an important research tool in such fast moving fields as guided missile development and atomic energy.

These solar furnaces no longer are considered mere laboratory toys. The more than 6,000 F heat (60% of the sun's surface temperature), which they generate, has made them the most versatile, inexpensive, and easily operated heat sources available today for high temperature research. Because many of the front-line technical developments now hinge on the solution of problems in this same high temperature range, it is little wonder that industrial firms as well as academic laboratories are becoming increasingly interested in solar furnaces.

In general, solar furnaces are simple in construction, although they demand precision workmanship. Most of them consist of three or four major parts: the focusing mirror (often a surplus military searchlight mirror), a driving mechanism to keep the apparatus properly trained on the sun, a holder for the material being heated, and a shutter system for regulating the focused beam. Some furnaces also have a heliostat, or plain mirror, which follows the sun and reflects its beams to the concave focusing mirror.

Solar furnaces have one obvious disadvantage: They do not work when the sun does not shine. However, meteorological studies have shown that even in the rugged climate of New England there will be enough clear days, on the average, to operate the new furnace at Arthur D. Little's (ADL) Cambridge Laboratories on a round-the-year basis.

In past years, most solar furnaces were custom built at individual sites. Now Arthur D. Little, Inc. is offering a commercial model to be produced to order using the ADL furnace as the prototype.

This furnace provides a compact, flexible tool for exposing materials to temperatures up to 3,500 C, over a circular area of 0.6 centimeter diameter.

The basic component of the furnace is a 60 inch diameter parabolic mirror with the front reflecting surface coated with stellite. Although the irradiated area of the sample is numerically small, it has been found suitable in many high temperature research investigations.

The area high temperature can be sharply defined and the desired temperature accurately controlled. Temperature and heat flux measurement can be made conveniently by inserting instruments through the viewing port at the back of the reflector.

The sample moving mechanism, made of light-weight material set in a mechanically rigid device, has a minimum frontal area to help reduce shadowing loss. The sample can be moved in directions parallel to the three co-ordinates. Variable speed motors, the controls for which are conveniently located at the base of the mirror support, permit regulation of the motion of the sample holder. For ease of inserting the sample, the sample moving mechanism can be rotated 180 degrees.

The stage for mounting the sample is so designed that the sample can be tested in air, under vacuum, or in other atmospheres. Temperature control is accomplished by means of a shielding cylinder.

Two motors permit rotation of the parabolic reflector around the horizontal and vertical axes. The sun can be tracked manually by sighting the sun in a collimating tube and using sensitive potentiometers to correct the basic tracking speed of the motors rotating the reflector.

Courtesy Pach Bros., N.Y.

SOLAR FURNACE, developed and produced for high temperature research laboratories.

Civilian Inventors Challenged by Armed Forces

Ideas of free lance inventors are needed right away to help solve nine "blue sky" problems which baffle the armed services, according to the National Inventors Council, U. S. Department of Commerce.

"We describe a problem as 'blue sky' when we suspect it will take imaginative, sky-is-the-limit thinking to solve it," explains J. C. Green, director of the Office of Technical Services and the Council's executive director. "The man who cracks one of these puzzles won't be bound by traditional barriers between sciences. He may have to be the modern equivalent of an Edison or Marconi—or even a Houdini."

The Council is the official clearinghouse for all inventions of potential value to the U. S. Government. Since 1940, this organization of scientists has examined more than a quarter of a million ideas submitted by amateur and professional inventors, passing those with merit along to the armed services. Many of these inventions, including the tropical dry cell battery and signal mirror, now are standard equipment in the U. S. Army, U. S. Navy and U. S. Air Force.

The nine revolutionary ideas needed by the armed services are:

Nonmagnetic compass. A device small enough to be carried by a man on foot which can determine true north, independently of the earth's magnetic field. Better still, it should enable a man to determine his position accurately.

Explosive Mine Detector. A method for locating explosives buried at shallow depths below the earth's surface. Present detectors locate the explosive's container or signal the presence of a hole in the ground.

Method for Converting Light into Electrical Energy. An invention which will convert a small amount of light into enough electricity to operate electrical equipment. Far greater power output is needed than has as yet been supplied by solar batteries.

Snow Track Eraser. A practical means of destroying the tell-tale tracks of men or vehicles across snow fields. Object is to restore original contour of snow field to avoid air detection.

Destructive Ray or Wave. Equipment of usable size capable of producing death rays effective at 500 yards—without excessive power input. Investigations so far indicate that a completely new approach is needed.

Universal Track. A new method of traction for land vehicles for use on all types of terrain. Present steel tank tracks wreck paved roads.

Radical Method of Unloading Ships. New means of quickly discharging large quantities of military supplies from commercial or military vessels, either over the beach or at dockside.

Vehicle Blackout Devices. Inventions to mask the light, noise, and radiation from combat vehicles operated under cover of darkness.

New Type of Communication. An ingenious new method of transmitting intelligence, nondetectable except by the desired receiver. The military is seeking a new principle which does not use electrical impulses, electromagnetic waves, or sound waves.

If anyone can come up with a practical idea for meeting one of these military objectives, he is encouraged to mail his solution to the Council. Complete lists of hundreds of technical problems affecting the national defense may be obtained by writing NIC, U. S. Department of Commerce, Washington 25, D. C.

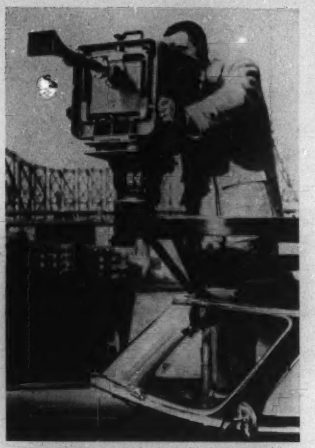
Tiny Antenna Horn Gives Mobile Inaugural Parade Coverage

The tiny Model *642* antenna horn, generally used by airlines and others for testing radar and microwave equipment, is now being used by the National Broadcasting Company (NBC) and American Broadcasting Company (ABC) to facilitate mobile television coverage of news and special events, after being successfully used for the first time by NBC at the recent Presidential Inaugural Parade in Washington.

Engineers of the NBC reporting units found the broad beam of this "C" Band Antenna Horn, manufactured by The Narda Corporation, Mineola, L. I., N. Y., even more suitable than "dish-type" parabolic antennas for covering such events as the Inaugural Parade, when distance from camera to relay transmitter is short and great mobility is required. In following the parade, the Narda horn, mounted with NBC's "traveling camera," on top of a specially modified Cadillac, beamed television signals to three microwave receivers. These were mounted on top of the Capitol dome, the roof of the Senate Office Building and the Mills Building. The broader beam of the horn antenna permitted less critical sighting between transmitter and receiver, eliminated considerable panning and helped maintain a television signal throughout the entire circuitous route of the parade.

A custom-made horn of a type similar to the Narda design was used by ABC in its parade coverage. So successful was the custom version of the Narda horn that ABC immediately installed a Narda horn as part of its mobile television "crash unit," a Dodge station wagon rebuilt and fitted out by ABC personnel. The "crash unit" will be used, according to ABC, "in emergencies, disasters like the Riker's Island plane crash, and special events demanding camera-in-motion treatment."

The Narda antenna horn covers a frequency range of 5,850 to 8,200 megacycles with a gain of 16.5 decibals and a beam



TRAVELING CAMERA unit, using a Narda antenna horn mounted on microwave transmitter instead of the usual parabolic "dish."

width of 28 degrees vertically and horizontally. Only 8 inches long and 4 inches by 4½ inches at its mouth, the aluminum horn weighs less than two pounds.

Thermal Measurements and Insulation Applications

The technical session of the ASTM Spring Meeting which highlights ASTM's Committee Week annually was held at the Benjamin Franklin Hotel, Philadelphia, Pa. The Symposium on Thermal Conductivity Measurements and Applications of Thermal Insulations provided about 200 members, committee members, and visitors with a variety of recent test data and information on the subject. The symposium was developed and sponsored by ASTM Committee C-16 on Thermal Insulating Materials and consisted of seven papers and lively extemporaneous discussions which made for a full and interesting afternoon.

The society proposes to publish the entire symposium as an ASTM Special Technical Publication which should be available sometime in late 1957. When available, it will be announced in the ASTM *Bulletin* and through the interested technical magazines.

Three-Part Unique Railroad Car

A railroad car in three parts—one part being the actual load the car is carrying—has been designed by Westinghouse Electric Corporation for transporting huge power transformers.

The unique car has a load capacity of 500,000 pounds, and will transport a transformer 28 feet long and 12 feet wide.

The car is comprised of two identical sections, each about 30 feet long. Each section consists basically of an underframe with trucks on which is mounted a steel truss. The transformer is suspended between the two trusses, forming the complete car. The primary benefit of the new car is that the transformer can be lowered to within about six inches of the rails. A heavy-duty car used now for shipping the largest transformers has about 48 inches clearance between rail and car bed.

By taking advantage of this extra clearance, many very large units can be shipped in one piece instead of splitting the top section, thus reducing installation costs and delivery time for customers.

Another important benefit cited was that the center of gravity of the load is lowered considerably, increasing load stability over that of conventional depressed-center car.

The two trusses, which are pivoted on the underframes, transmit the weight of the load, and their own weight, to the underframes at two vertical load centers located midway between trucks.

One of the special features of the car is that pivot points are offset from the load centers of the car. Because load centers must move laterally on curves, they are mounted on roller nests to reduce friction.

This offset arrangement permits the car, which has an over-all length of about 90 feet when carrying a transformer 28 feet long between car connections, to negotiate the same curves as a standard boxcar. Previous special depressed-center cars used for transporting very large transformers required a much greater turning radius, which complicated routing problems and usually required a longer shipping time.

Two 100-ton hydraulic jacks are located at each load center to facilitate loading and unloading of transformers. In addition, two 30-ton jacks are located near each pivot point for manipulation of the truss during loading and unloading.

Not all transformers could be shipped on such a car, however, but the shell-form, Form-Fit (registered trade mark) transformer built by Westinghouse lends itself readily to this type of shipment inasmuch as the core and coils are supported by a step or flange in the bottom section of the tank instead of resting on the tank bottom.

All-Transistor Midget Computer for ARDC

A transportable midget computer that can add, subtract, multiply, and divide 1,000 times faster than the familiar desk calculator, has been developed for the Air Research and Development Command (ARDC) by Autonetics, division of North American Aviation, Inc.

The first model produced of this general-purpose, all-transistor digital computer, has been delivered and is in use at ARDC's Rome Air Development Center, Rome, New York.

The miniature computer, called RECOMP by the manufacturer, is much smaller by comparison with computers of similar type and capacity. Most computers of similar type and capacity would require space the size of an average living room for housing, while the RECOMP is the approximate size of a 27-inch television set. Nevertheless, its capability as well as its reliability equals and exceeds that of many much larger machines.

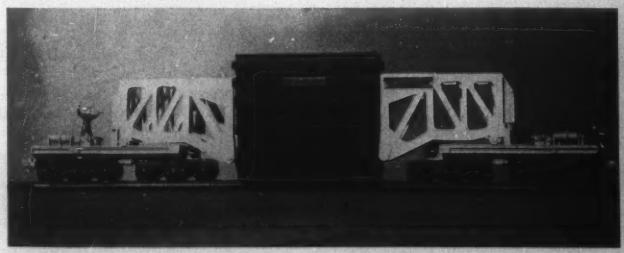
The computer package weighs only about 200 pounds and measures a mere 6-cubic feet. It can be lifted easily by two or three men and transported in a small vehicle.

Ready to work when plugged in, it operates on less current than an electric toaster. No installation or set-up time is required. Environment is of small concern in operating this computer. Heat dissipation is no problem: cooling is performed automatically by a built-in refrigeration system that keeps proper temperature and allows operation in any natural environment up to 120 F.

Rugged design makes "kid-gloves" handling unnecessary. It has no vacuum tubes to be damaged in transit. Reliability has been verified by operational tests that indicate performance has not been sacrificed for its small size, its ruggedness, and its mobility.

Constructed to allow easy maintenance, the unit's circuitry consists of small etched-circuit plug-in boards of relatively few standard types. These rigid, circuit boards are mounted on hinged panels so that all components and wiring are readily accessible for checking and servicing. Replacement is as simple as changing an electric light bulb.

The computer is augmented by a separate self-contained test console that reduces troubleshooting and maintenance time to a minimum. Self-checking features eliminate input-output errors, automatically verify stored information, and immediately detect any malfunction of input equipment or their circuitry.



MODEL of new railway car loaded with large transformer. Two halves hook together for return trip. Short turning radius, made possible by offset pivots and traversing load centers, allows loaded car to take curves with great ease.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Generator Saturation Curve

To the Editor:

A number of approximations to the open-circuit saturation curve of a generator have been published. The simplest and probably the one used most often is the Froehlich approximation given by

$$V = k\phi = \frac{I_f}{A + BI_f}$$

where V is the terminal voltage, ϕ the air-gap flux, and I_f the generator field current. The constants A and B are then determined from the experimental curve by some method such as least squares. Fourier series, etc.

One usually finds that simple approximations do not fit well enough at times to give calculations (using the approximation) sufficient accuracy or that complex expressions are too time-consuming to determine the necessary constants.

The writer believes that his approximation is both simple and accurate enough to obviate the aforementioned objections.

If one takes the Froehlich approximation and rewrites it so that it appears as

$$\frac{I_f}{V} = A + BI_f$$

and letting

$$\frac{I_f}{V} = y$$

then

$$y = BI_f + A$$

This is the equation of a straight line. If the Froehlich approximation were exact, we would get the solid line of Fig. 1. However, experimentally we get the dashed line of Fig. 1, and so we know that the Froehlich approximation must be modified.

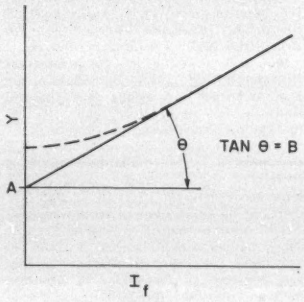


Fig. 1

Calling the solid line y_1 and the dashed line y_2 we take a new variable x, where

$$x = y_2 - y_1$$

Plotting the variable x against I_f we get the curve shown in Fig. 2. This curve can

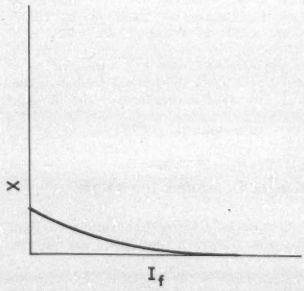


Fig. 2

be approximated by several functions. The one taken here, since it gave the best fit, was an exponential given by

$$x = Ce^{-DI_f}$$

Taking the logarithm of each side,

$$\log x = \log C - DI_f$$

If this is plotted on semilog paper we get the curve as seen in Fig. 3.

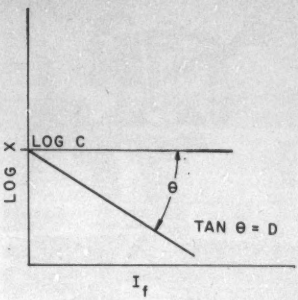


Fig. 3

The two constants C and D are readily determined. If the plot is not a reasonably straight line, a different approximation can be resorted to at the discretion of the individual.

Reversing the foregoing procedure then gives the new approximation to the saturation curve as follows

$$V = \frac{I_f}{A + BI_f + Ce^{-DI_f}}$$

This approximation has given the writer excellent results and he forwards this letter in the hope it will prove of value to others.

D. S. TOFFOLO (AM '55

(Code 5232, Naval Research Laboratory)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

HIGH TEMPERATURE—A TOOL FOR THE FUTURE. Proceedings of a Symposium, Berkeley, Calif., June 1956. Published 1956 by Stanford Research Institute, Menlo Park, Calif. 218 pages, 8½ by 11 inches, bound. $5. The 36 papers included are about evenly divided among three major subjects: methods for obtaining high temperatures, materials for containing high temperatures, and processes occurring at high temperatures. The methods treated include solar furnaces, the carbon-arc image furnace, short time electrical discharges, induction and resistance heating, chemical methods, and nuclear methods. Papers devoted to materials deal with ductile ceramics, refractory coatings, selection of materials, and the interactions of materials with high temperature environments. Gas and condensed state reactions, and the interactions between gases and condensed phases are the chief process discussed.

ALTERNATING CURRENT BRIDGE METHODS. By B. Hague. Pitman Publishing Corporation, 2 W. 45th St., New York 19, N. Y., fifth edition, 1957. 650 pages, 5½ by 8¾ inches, bound. $12.50. The text basically is that of the fifth edition, but certain errors and repetitions have been removed. Fundamental principles have

been restated in mks units. Descriptive matter has been revised and modernized, and the supplementary use of coupled inductive ratio arms and the wider application of bridged-T and parallel-T networks is discussed, as are the Schering bridge and a few new bridges, mainly for frequency measurement. Inasmuch as this is intended as a handbook, the fundamental theory of the use of a-c bridge networks and its practical applications are thoroughly treated.

BASIC ELECTRICAL ENGINEERING. By A. E. Fitzgerald and D. E. Higginbotham. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., second edition, 1957. 540 pages, 6 by 9¼ inches, bound. $7.50. This second edition incorporates recent developments in circuit theory, electrical machinery, industrial electronics, and control and measurement techniques and systems, which are the four main divisions. New material is presented on magnetic amplifiers, transistors, self-balancing recorders and controllers, phase-sensitive modulation and demodulation, control amplifiers, d-c and a-c control motors, transfer functions, and frequency-response analysis. A side selection of problems and examples is included.

THE CATHODE RAY OSCILLOSCOPE. By J. Czech. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1952. 340 pages, 6 by 9⅛ inches, bound. $8.50. Part I of this text comprehensively covers the structural details, circuitry, and method of operation of the oscilloscope with original oscillograms by the author. Part II is concerned with the general measuring techniques used. Part III gives measurements taken in actual practice and the methods of evaluation of these results including a discussion of the value of a time base expansion unit in these investigations. Part IV includes complete instructions for the construction of a small, simplified oscilloscope, a high precision instrument, and a time base expansion unit. An extensive bibliography is included.

ELECTRIC CIRCUITS AND MACHINES. By B. L. Robertson and L. J. Black. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., second edition, 1957. 456 pages, 6 by 9¼ inches, bound. $6.75. The general scope of this book includes the major subjects of circuits, machines, electronics, and instruments, with considerable stress on single-phase circuit theory. In the revision, sections have been added on transistors, crystal diodes, and the resistance strain gauge, and an appendix on the magnetic circuit has been included. Also, numerous problems have been added and some of the older ones replaced or revised.

ENGINEERING AND TECHNICAL HANDBOOK. By D. C. McNeese and A. L. Hoag. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1957. 376 pages, 4⅞ by 7⅞ inches, bound. $6. This concise handbook is divided into five parts: basic formulas and fundamentals which may be applied to both engineering and physics; general information such as atomic weights and constants of the elements, strength of materials, coefficients of friction, and kinetic viscosity of various fluids; an alphabetical listing of units with their equivalents; mathematical computations ranging from arithmetic to integral calculus with illustrative examples; and the mathematical tables generally used in engineering and allied fields.

ESSENTIAL FACTORS IN THE FUTURE DEVELOPMENT OF THE PETROLEUM INDUSTRY. Edited by George Sell. Institute of Petroleum, London, England, 1956. 176 pages, 5½ by 8¾ inches, bound. $2. This volume consists of the papers, with discussion, that were presented at the 1956 summer meeting of the Institute of Petroleum. The subjects of the papers are as follows: world energy demand and the prospects for solid, liquid, and gaseous fuels and hydroelectricity; the economics and application of atomic energy; probable oil demand; oil resources; methods of transport; refining techniques; oil as a source of chemicals; and financial aspects of oil industry developments.

DAS FERNMELDERELAIS. By M. Hebel. R. Oldenbourg, Munich, Germany, 184 pages, 6 by 9½ inches, bound. DM 28. This essentially descriptive textbook on telecommunication relays covers the following: electrophysical fundamentals; measurement of tripping time; contacts; neutral, a-c, and polarized relays; relays with sequence action; time-delay and thermally activated relays; cross bar systems; multicontact relays; and other special designs.

A HISTORY OF TECHNOLOGY. Volume 2. The Mediterranean Civilizations and the Middle Ages. Edited by Charles Singer and others. Oxford University Press, 114 Fifth Ave., New York 11, N. Y., 1956. 802 pages, 7¼ by 10 inches, bound. $26.90. This is the second volume of a series of five which will cover the development of technology from the Old Stone Age to the late 19th century. The first volume, already published, was from early times to the fall of ancient empires c. 500 B.C. The present volume covers the Mediterranean civilizations and the Middle Ages. Only the technology of Europe is dealt with, and coverage is mainly with the development of processes, techniques, and devices rather than with social and economic implications. The range of subjects includes all those activities which provide for material needs: mining, quarrying, metallurgy, agriculture, leather, textiles, ceramics, glass, building construction, transportation, metal work, machinery, power, hydraulic engineering, and sanitation. Six hundred ninety-five illustrations including maps and diagrams and an additional 44 plates are provided. Literature sources are found at the end of each chapter, and personal and place name indexes are appended.

AN INTRODUCTION TO INJUNCTION TRANSISTOR THEORY. By R. D. Middlebrook. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1957. 296 pages, 5⅞ by 9¼ inches, bound. $8.50. This study is intended to bridge the gap between solid-state physics and the circuit properties of a junction transistor for the electronic engineer. It develops the basic theory of transistor action from the discussion of crystalline structure and electron movement in crystals to the setting up of a representative small-signal equivalent circuit. This circuit is suitable for use in the design of small-signal amplifiers covering the entire useful range of the transistor. For the circuit designer, formulas are given for its transformation to a form usable in a practical transistor.

INTRODUCTION TO OPERATIONS RESEARCH. By C. W. Churchman and others. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1957. 645 pages, 5⅞ by 9¼ inches, bound. $12. A general survey of this rapidly growing field is presented with particular reference to industry covering such subjects as inventory, waiting-time, allocation, and replacement models. The setup of scientifically valid conditions for model testing, including the defining of properties and conditions of observation, and the checking of test results, is the subject of a later chapter. The concluding parts deal with the control and carrying out of the solution in actual practice, and with administration problems. Case histories illustrate each method, and models and chapter bibliographies provide for further reading.

MATHEMATICS AND COMPUTERS. By G. R. Stibitz and J. A. Larrivee. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1957. 228 pages, 5⅞ by 9¼ inches, bound. $5. A general introduction to computation methods and devices, intended to give to the nonspecialist an understanding of basic concepts. Types of problems solved by computers, components, and logical design of digital computers; analog computers and simulators; random numbers; numerical analysis; and applications are covered.

MECHANISMS AND DYNAMICS OF MACHINERY. By H. H. Mabie and F. W. Ocvirk. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1957. 442 pages, 6 by 9¼ inches, bound. $8.50. A two-part introductory text. Part one covers linkages, cams, gears, gear trains, and the elements of computing mechanisms and four-bar linkage. Part two covers kinematics of machinery, force analysis, balance, and vibation.

PATENT NOTES FOR ENGINEERS. By C. D. Tuska. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., seventh edition, 1956. 192 pages, 6 by 9¼ inches, bound. $4. This is a discussion of the practical problems that arise from the moment of conception of a patentable invention to the acquiring of patent rights. Illustrated by numerous cases and examples, the discussion covers invention as defined in patent law, the need for good records and adequate disclosures, the preparation and prosecution of applicants, and the ownership and use of patents.

PHYSICAL BASIS FOR ELECTRICAL ENGINEERING. By T. L. Martin, Jr. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1957. 410 pages, 5¾ by 8¾ inches, bound. $10. This textbook is concerned with the broad physical basis of electrical engineering phenomena; theory and concept are stressed rather than experimental or analytical methods. Both the macroscopic and microscopic viewpoint are presented. The chapters contain material on electrostatic and static magnetic fields in vacuum, extranuclear atomic structure, nuclear structure, structure and behavior of metals, semiconductors and semiconductor devices, vacuum tubes, insulators and capacitors, magnetic properties of matter, and inductance. Problems are given at the end of each chapter, and charts and diagrams are included throughout.

POWER RESOURCES OF YUGOSLAVIA. Volume I, Water Power Resources of Yugoslavia. Edited and Published 1956 by the Yugoslav National Committee of the World Power Conference, Belgrade, Yugoslavia. 456 pages, 9¾ by 13⅜ inches, bound. $25. Part I of this large volume consists of some 200 pages of detailed exposition of methods used in evaluation of water power resources, intended for hydrologists and hydroelectric engineers. Part II provides a detailed examination of the 33 drainage basins into which the country has been divided. The theoretical potential due to run-off water is evaluated at 212 billion kw-hr per year and the net potential at 89 billion kw-hr per year, which offers a scope that should be of great interest to engineers. The book is printed in parallel columns of Serbo-Croat and English text, and contains a wealth of diagrams and illustrations with bilingual captions.

PRINCIPLES OF ENGINEERING HEAT TRANSFER. By W. H. Giedt. D. Van Nostrand Company, Inc., 120 Alexander Street, Princeton, N. J., 1957. 372 pages, 6 by 9¾ inches, bound. $8.25. A text for third-year students, covering energy transfer, fluid flow, conduction, convection, and radiation. The book has been designed to meet the needs of electrical and industrial as well as mechanical engineering students.

PRODUCTION FORECASTING, PLANNING, AND CONTROL. By E. H. MacNiece. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., second edition, 1957. 374 pages, 5¾ by 9¼ inches, bound. $8.25. The engineering principles of production management are emphasized in this book, with effective applications of these principles and their economic and social implications. Some new features are chapters on automation, specialization, standardization and simplification, level production and its relation to the guaranteed annual wage, and a report on production engineering education and practices in Europe. A bibliography lists general references for each chapter.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

TRANSISTOR MANUAL. The General Electric Company has announced publication of this booklet containing basic information on transistors and their operation in circuits. The booklet is designed to assist the service technician, hobbyist, and design engineer in working with transistors. The manual includes information on basic semiconductor theory, construction techniques used to make the various types of transistors now on the market, basic principles of transistor circuit design, and specifications, with outline drawings, of all transistors registered with the Radio-Electronic-Television Manufacturers Association. In addition, the booklet also contains complete explanations of transistor parameter symbols now in common use. There are 19 circuit diagrams ranging in complexity from a one-transistor simple audio-amplifier to a six-transistor superheterodyne broadcast receiver included with complete parts list for the hobbyist and experimenter. A cross-reference chart for replacement of transistors in current transistorized radios of all manufacturers is also included. The new booklet is priced at 50¢. It may be obtained by writing to the Semiconductor Products Department, General Electric Company, Syracuse, N. Y., or from local General Electric tube and transistor distributors.

SELECTED ASTM ENGINEERING MATERIALS STANDARDS FOR USE IN COLLEGE CURRICULA. 370 pages, price: $4.00 list, $1.50 to students of recognized engineering colleges. This compilation has been prepared for use by college engineering students and teaching staffs. By supplying representative illustrations of nationally accepted standard specifications and the standard test methods which support them, the student can be made familiar with the existence, availability, nature, and origin of the specifications for the materials which all engineers must use. Specific standards were selected on the basis of a poll among engineering educators. They are intended to include not only the standards most closely linked to the work of the course, but also standards that illustrate the varied nature and approach to problems of standardization. Introductory and supplementary material to provide background and breadth of grasp has been included. The condensation of the 1907 American Society for Testing Materials (ASTM) presidential inaugural address by C. B. Dudley points up the need for standards and illustrates the variety both of the tangible and psychological problems that relate to their use. The modern engineer should also have some appreciation of the legal aspects of standardization and that, too, is given limited attention. Although the compilation is intended to be closely correlated with the formal course work in materials and materials testing, it is not in any sense a textbook; it is a supplement rather than a replacement. Copies of the book may be obtained from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

BLUEPRINT READING. A basic reference work prepared for the specific needs of technicians, teachers, and students who must use blueprints in their work or studies. Prepared by the Chief of Naval Air Technical Training and the Bureau of Naval Personnel, the book includes the uses and kinds of blueprints and an explanation of blueprint language, including lines, sections, symbols, dimensions, conventions, notes, and titles. A layout section covers layout tools and how they are used, layout geometry, and the equipment and area needed for competent layout work. Also covered are curve or bend allowance, templates, developments, electrical blueprints, mechanical and piping systems, welding symbols, and architectural and structural drawings. All symbols used in the various types of prints are provided. Sections on wiring and schematic diagrams have been prepared in accordance with the increased training demands of electrical and electronic equipment. Each chapter is followed by a model quiz on the material in it. The book has three appendixes and is completely indexed. Several line drawings illustrate the text. 256 pages, illustrated, appendices, index: $3. Published by Arco Publishing Company, 480 Lexington Ave., New York 17, N. Y.

ENGINEERING REGISTRATION EXAMINATION BOOK. A newly enlarged and revised book is now available covering examinations given by the state of California for the registration of civil engineers and engineers in training. The examinations given between 1940 and July of 1949 include the unofficial solutions of the problems by the author and the balance of the examinations from July of 1949 to and including June 1956 include the problems only. All options for the civil engineers examinations are included together with the engineers in training examinations for all branches of engineering. The book, containing 381 pages, may be ordered from the author: August E. Waegemann, 2833 Webster St., San Francisco 23, Calif. Send $7 plus tax and receive the book postage free or send request only and receive the book C.O.D. plus postage.

THE PUNCHED CARD ANNUAL OF MACHINE ACCOUNTING AND DATA PROCESSING. The latest issue, Volume Five, is divided into two sections—a management section and an applications section. Four volumes were previously published, all of which provide a wide variety of material of interest to both top management and operational personnel in practically every type of business, industry, or civilian or Government institutions. Each volume contains more than 200 pages and the 5 volumes are completely cross-indexed. More than 500 articles are included in the five volume set. The complete set of five volumes is priced at $37.50, or the latest single volume (Volume Five) at $8.50 (plus postage). Order directly from The Punched Card, 836 Maccabees Building, Detroit 2, Mich.

SERIES-TUBE CORE MEMORY. A high-speed core memory for digital computers using a selection system which does not require close control of the characteristics of the magnetic cores has been developed by the Air Force. The research is described in a report released for industry use through the Office of Technical Services (OTS), U. S. Department of Commerce. The basic problem in the use of magnetic cores for permanent high-speed storage was the selection of the few cores representing a storage register and providing, with a minimum of driving tubes, the high currents necessary for reading out or writing information into this register. A solution was provided by a series-tube core memory, similar in operation to the coincident-current memory and using the same storage element as that system and the core-diode memory. The scheme uses a diode with each core. The resulting core memory achieves a random access time of two microseconds, the same speed as the coincident-current memory, but uses fewer tubes. It is not amplitude sensitive and does not require matching of cores. The report contains a theoretical analysis and synthesis procedure for the series-type driving circuit. Experimental results from the operation of 16 single-bit registers with the series-tube selection also is included. The volume, *PB 121558*, E. J. Otis, Air Force Cambridge Research Center, September 1955, may be ordered from OTS, U. S. Department of Commerce, Washington 25, D.C. It contains 44 pages, price $1.25.

IMPROVING HUMAN RELATIONS. In this booklet, the National Association of Manufacturers (NAM) presents an action program which is designed to help top management develop better supervisor–employee relations in the plant and, thus, step up productivity. Pointing out that the successs of a company "rests heavily on how well the management group performs in achieving person-to-person understanding," the booklet emphasizes that the supervisor, as a member of management, must "listen" to employees and understand their needs and wants. The NAM says it is most important for supervisors to listen to employees with understanding and try to interpret what they have to say, whether it is just a gripe, a more serious complaint, a suggestion, or the expression of an opinion. Thus, it says, supervisors can identify friction spots that need clearing up and can "build the team spirit so essential to lower costs and greater productivity." The booklet points up the possibilities of getting co-operation and building good work habits through the wise use of praise and a "pat on the back" where warranted (as distinguished from flattery). It urges genuine interest in employees as individuals, apart from their function as "producers." Sound personnel policies, enlightened leadership, and effective day-to-day communication between all levels of management, according to the NAM, are the ingredients of good human relations in the plant. The booklet presents practical steps to guide management in giving foremen and other supervisors the kind of training, education, and support they need to fulfill their vital function. Copies, at 50¢ each, are available from the NAM Employee Relations Department, 2 East 48th St., New York 17, N.Y.

GOVERNMENT ELECTRONICS RESEARCH, A BIBLIOGRAPHY OF RESEARCH REPORTS RELEASED THROUGH THE OFFICE OF TECHNICAL SERVICES, JANUARY–DECEMBER 1956. *PB 121779*, 50 pages, price $1.50, may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C. A bibliography of electronics research reports released to the public in 1956 by the Army, Navy, and Air Force through the Office of Technical Services, U. S. Department of Commerce. OTS is the Government's clearinghouse for reports of Government financed research of interest to the nation's scientific and industrial public. Some of the reports listed in the bibliography may be purchased in printed form from OTS. Others are available in microfilm or photocopy from the Library of Congress.

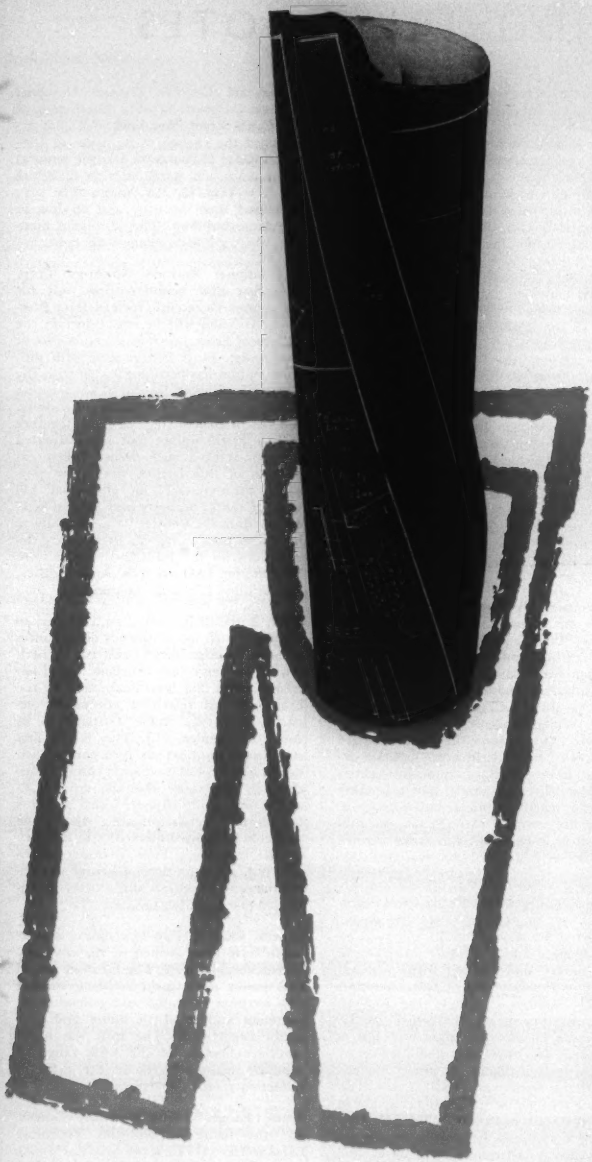
TENTATIVE SPECIFICATION FOR BRAZING FILLER METAL. An improved edition of the Specification for Brazing Filler Metal has been issued jointly by the American Welding Society (AWS) and the American Society for Testing Materials. (ASTM). The 29 classifications included in this edition (AWS *A5.8*; ASTM *B260*) cover every type of brazing filler metal in common use today. They are grouped, according to principal constituents, into 7 types: (1.) aluminum-silicon, (2.) copper-phosphorus, (3.) silver, (4.) copper-gold, (5.) copper and copper-zinc, (6.) magnesium, and (7.) heat-resisting materials. The new revision provides details on chemical compositions of the filler metals, standard sizes and lengths, packaging, and marking. A handy appendix, intended as a guide in the selection of the best filler metal for a given application, contains data on the use of each classification. This includes brazing temperature ranges, joint designs, joint clearances, color of the brazed joint, and information on many other properties. Copies of this specification can be obtained at 40¢ each from the American Welding Society, 33 W. 39th St., New York 18, N. Y., or the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

ABSORPTION SPECTRAL INDEX PUNCHED CARDS. The American Society for Testing Materials offers three sets of punched card indexes to absorption spectral data. These cards were prepared by Committee E-13 on Absorption Spectroscopy. Included are empirical formula name index for infrared spectra, spectral absorption index for infrared spectra, and a spectral index for ultraviolet absorption spectra. The empirical formula name index for infrared spectra now totals 13,899 cards. These cover the same compounds included in the first 10,969 spectral absorption infrared index. The additional cards are used where the length of the name or formula required a second card to record the data. The entire spectral absorption index for infrared totals 12,766 cards. There are 7,066 cards in the ultraviolet set. Details concerning the sources of data, prices, instructions for use, and availability of cards may be obtained from the American Society for Testing Materials, Attention: K. Guthrie, 1916 Race St., Philadelphia 3, Pa.

THE STUDY OF PROPERTIES OF SINGLE CRYSTALS FOR USE AS DETECTORS AND CRYSTAL COUNTERS. S. J. Czyzak and others, University of Detroit for Office of Naval Research. October 1955. 42 pages. $1.25. (Order *PB 121517* from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.) Single crystals of cadmium sulfide and zinc sulfide were grown and their optical, electrical, and structural properties studied during this investigation of potential use of the crystals as infrared detectors and crystal counters. Results of the work provide both a source of fundamental research data and an aid to the solution of applied problems, such as prediction of the usefulness of certain crystals. A procedure is given for growing single synthetic crystals with, and without, controlled impurity additions such as indium, magnesium, lead, and oxygen. The crystals were examined for index of refraction, absorption coefficient, dielectric constant, resistivity, photoconductivity, rectification, and photovoltaic effects. Preliminary experiments also were made on the radiation effects from high energy electrons.

DEVELOPMENT OF FERROELECTRIC CERAMICS. J. D. Wallace and M. F. Pressler, U. S. Naval Air Development Center. February 1953. 59 pages. $1.50. (Order *PB 121418* from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.) Facilities and methods devised by the U. S. Navy for the ceramic forming of transducers of barium titanate are described. Production relies on a technique of slip casting which reduces the formation of an optimum slip to a scientific procedure and produces yields of above 80% of pieces with densities greater than 5.50. Test pieces of 94% barium titanate, 4% lead titanate and 2% barium stannate were formed which showed considerable promise for use as transducer elements in hydrophones. Laboratory facilities are described by text and photographs in the report, along with methods of evaluating the transducers.

ASME STANDARD A GLOSSARY OF TERMS IN NUCLEAR SCIENCE AND TECHNOLOGY. The new American Society of Mechanical Engineers (ASME) Standard A Glossary of Terms in Nuclear Science and Technology, *No. 110*—1957, has been completed. Copies may be obtained from Order Department, The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y. at $5 per copy.



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INDUSTRIAL NOTES

Atomic Industry Opinion Poll. An opinion poll of the American atomic industry has revealed that lack of economic inventive, inadequate insurance protection, and secrecy policies of the Government are considered to be the three main factors limiting the development of atomic energy for peaceful purposes. The poll was conducted during December 1956 by the Atomic Industrial Forum, Inc., a nonprofit association of over 500 industrial, educational, labor, and research organizations in the United States and abroad. Opinions were solicited from the 427 organization members of the Forum in the United States and 167 responded. The opinion poll was undertaken by the Forum in an effort to identify those problems, if any, which may be inhibiting the growth and development of the atomic industry in order that the Forum could plan its future activities to be of maximum usefulness to its membership. The Forum said that the anonymity of respondents was preserved so that no consideration other than the opinion of respondents could influence the results. Each respondent was asked, however, to indicate the type of organization for which he was reporting.

Substations for Academy. The United States Air Force Academy, near Colorado Springs, Colo., will receive electric energy for lighting and general-purpose loads through two outdoor-type, package-master unit substations supplied by General Electric's medium voltage switchgear department. Among Academy facilities scheduled to receive power from the substations are classrooms, the airfield area, football stadium, fire station, community center, bachelor officers' quarters, and a housing area for married officers and instructors. Electricity provided through the new substations will be about the same amount required by a city of 20,000 persons.

Cabinet Roller Slide. Ready accessibility to cabinet mounted electronic equipment is offered by Chassis-Trak roller slides. Chassis glide out at a touch on stainless steel rollers, and can be tilted up and down for fast servicing of both tube and circuitry sections. The new slide has the same ultrathin design, 0.350 inch, as the company's solid-bearing slide line, but is supported by heavy duty stainless steel rollers. It is available in three models, the Detent, Basic, and Cradle Track. The Detent, for mobile installations or above eye level, tilt-locks in seven different UP–DOWN positions. It provides maximum access to installations. The Basic, for stationary installations, tilts back for servicing. The Cradle Track is a prealigned assembly for fast installation in either cabinets or racks. The roller slides come in eight stock lengths for mounting 17-inch wide chassis in standard 19-inch wide cabinets. Load capacity in fully extended position is 175 pounds. For full details write Chassis-Trak, Inc., 525 S. Webster St., Indianapolis, Ind.

Name and Location Change. Universal General Corporation, relay distributors, of 324 Canal Street, New York, N.Y., has announced the change of its name to Universal Relay Corporation and the removal of its office and warehouses to 42 White St., New York 13, N.Y. where they have combined their facilities and services in one large building. The telephone number, WAlker 5-9642, remains the same.

International Business Machines Corp. The first new manufacturing unit for the company's recently formed Data Processing Division will be established in the Village of Essex Junction six miles east of Burlington, Vt. A 10-year lease with purchase option has been negotiated with the Greater Burlington Industrial Corporation (GBIC), and with its subsidiary, Cynosure, Inc., for a 20-acre tract of land, together with a 40,000 square foot plant situated thereon. With a view toward future expansion of this facility, options to purchase approximately an additional 240 acres of GBIC property and private acreage north of the Central Vermont Railway have also been obtained. Preliminary negotiations for the lease and options were handled for IBM by The Allen Agency, Inc., realtors in the Burlington area.

RCA. A stabilizing amplifier, designed to eliminate such low frequency disturbances as hum, bounce, surges, and tilt in both low color and monochrome television transmissions, has been announced by the broadcast and television equipment department of the Radio Corporation of America, Camden, N.J. This is the first stabilizing amplifier to incorporate such design advances as a separate chrominance channel, luminance channel, sync AGC, and a peak white clipper, which prevents transmitter over-modulation. Also made available in limited quantities to industry by the company's Tube Division, Harrison, N.J. are four developmental electroluminescent phosphors and a developmental photo-conductive powder.

General Electric. Two new motor departments have been formed by the company in Schenectady, N. Y. The medium induction motor department is being divided into medium a-c motor and generator department and small a-c motor and generator department. The split was made necessary because of the wide range of products manufactured by the medium induction motor department.

Name Change. Nothing has really changed but the name of Houston Technical Laboratories (HTL), a subsidiary of Texas Instruments Incorporated. The new name is Texas Instruments Incorporated (TI), Industrial Instrumentation Division, 3609 Buffalo Speedway, Houston, Tex. This change of HTL from a subsidiary to a TI Division was effected merely to simplify the corporate structure of Texas Instruments Incorporated. The company will continue under the same management.

(Continued on page 21A)

(Continued from page 18A)

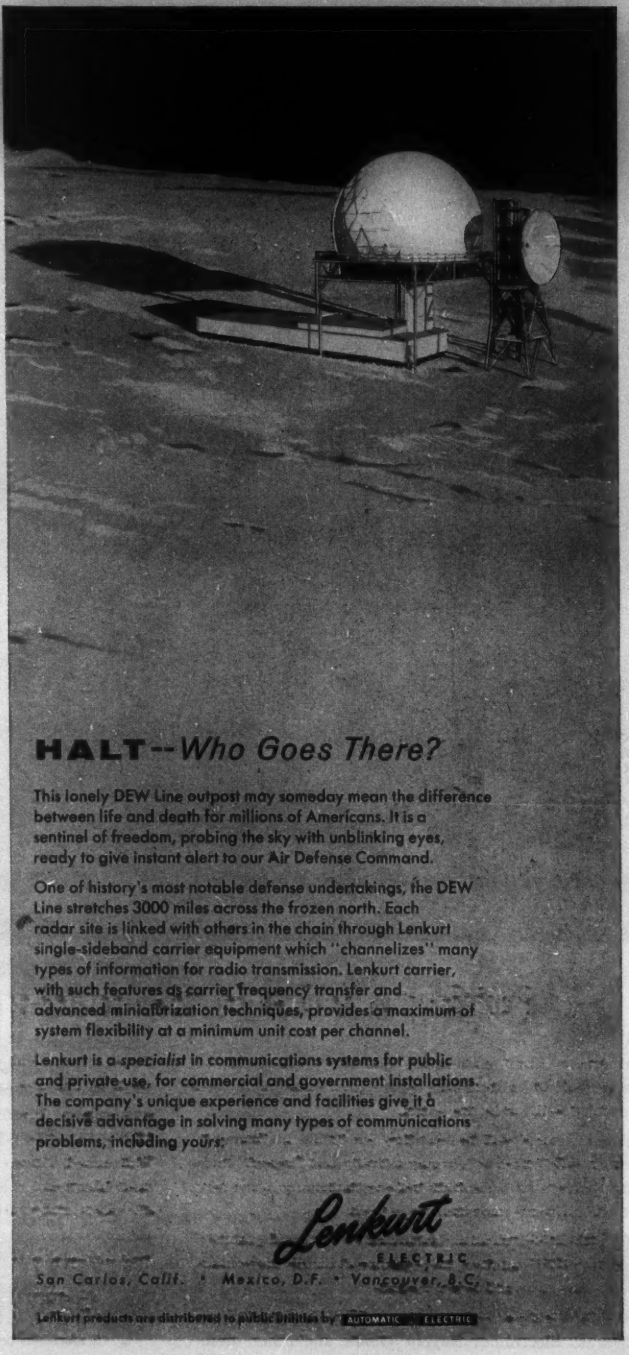
Industrial Notes

All-Metal Mounting System. Robinson Aviation, Inc., Teterboro, N. J., designers and manufacturers of all-metal vibration and shock mounting systems, have developed a Met-L-Flex center-of-gravity mounting for a pressure ratio transmitter unit developed by Minneapolis-Honeywell Regulator Co. for airborne applications. This specialized mounting system incorporates pressure and electrical connectors as part of the supporting structure of the mounting. This provides for ease of installation and in effect combines the equipment and mounting into an integral package. Constructed of aluminum and steel throughout, this lightweight mounting system is a permanent type mounting unaffected by adverse operating conditions. The incorporation of Met-L-Flex resilient elements, located in the plane of the center-of-gravity, provides Model *1,323* with environmental tolerance from vibration and shock thereby insuring equipment reliability. The high percentage of inherent damping displayed by the mounting system results in the reduction of resonant peaks and the quick dissipation of transient forces. The natural frequency of Model *1,323* is between 6 to 11 cycles per second (cps) while the amount of vibration isolation provided is approximately 90% at 40 cps. Designed in accordance with military specifications *MIL-E-5272A*, *MIL-C-5541*, and *QQ-P-416*, this mounting system is readily adaptable to military applications. Modifications are available upon request. For further information consult the manufacturer.

New Plant. General Electronic Laboratories, Inc. (G.E.L.), has expanded its facilities to include a modern three-story 16,000-square-foot plant on Massachusetts Ave., Cambridge, Mass. This expands the facilities to 40,000 square feet. The additional space will be used primarily for manufacturing purposes allowing the use of the present production area for engineering expansion. During the past year G.E.L. has also established a new research and development facility in Silver Spring, Md. This facility is presently in operation on military programs.

Silicon Production Plant. The United States' first full-scale plant for the production of hyper-pure silicon, a vital part of many electronic and electrical devices, will be constructed on a large tract of rolling timberland near Brevard, N. C., by E. I. du Pont de Nemours & Co. (Inc.), Wilmington, Del. The plant is expected to be ready for operation early in 1958. The new facility, to be operated by the pigments department, will be known as the Brevard Plant. The plant is expected to produce about 50,000 pounds of semiconductor grade silicon annually. This is the material used in the manufacture of such devices as transistors, diodes, and power rectifiers.

(Continued on page 24A)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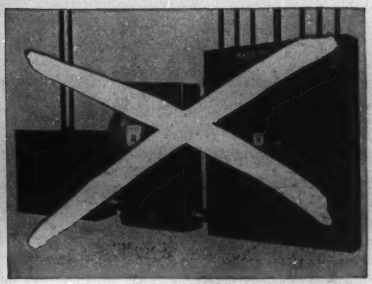

above • the old way of installing service entrance—a C/T cabinet, a large safety switch and a panel board or a gang of smaller safety switches were hung on a wall and connected by a complicated arrangement of wireway or conduit and cable. Expensive, space-consuming and unsightly.

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(Continued from page 21A)

NEW PRODUCTS

Battery Breakage Eliminated. A material for industrial storage battery cell containers and covers that virtually eliminates battery breakage has been announced by C & D Batteries, Inc., Washington and Cherry Streets, Conshohocken, Pa. The material, called Hi-Impac, was developed jointly by the research department of C & D and those of major rubber companies. It replaces present standard materials in the C & D Slyver-Clad *R* line for industrial trucks and mine batteries. As a result of using the new Hi-Impac material, damage to battery cells from dropping, collision between trucks, or from the impact of heavy objects falling on the battery is practically eliminated. This greatly reduces the necessity of sending the battery back to the shop for repairs. In field testing, no replacement of the new material has been required in a year and a half.

Silicon Rectifier Units. A complete line of silicon automatically regulated power rectifiers recently unveiled by Christie Electric Corp., promises to play a vital role in the aircraft, electronic, and industrial fields. This standard line up to 1,000 amperes continuous capacity, is proving particularly useful as the d-c source for ground support equipment and missile testing. Reliable performance is assured with the hermetically sealed silicon diodes which are impervious to humidity, fungus, salt spray, sand and dust, as well as extreme ambient temperatures. Longer life and higher efficiency is combined with lighter weight and smaller size. The wide range of operating temperatures —55C to +65C make them suitable for use under the most extreme climatic conditions. All models are built to meet the requirements of military specifications. For more detailed information write Christie Electric Corp., 3410 W. 67th St., Dept. S13, Los Angeles 43, Calif.

Multichannel Programming Device. The *MPR-13* Multichannel programmer is small in size and light in weight, and yet provides up to 13 channels for any type of electrical programming, either of a repeat cycling or of a random nature. It has an accuracy of the order of one part in approximately 50,000, even though it was designed to withstand the rigors of missile and aircraft usage. For utmost ruggedness, the programmer is manufactured to extremely close tolerances, and is housed in a magnesium casting for a high degree of strength and resistance to shock and vibration without imposing a high weight penalty. For additional information and prices of the Programmer *MPR-13*, write direct to the manufacturer, Photographic Products Inc., 1000 No. Olive St., Anaheim, Calif.

(Continued on page 32A)

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with G-E Inductrol* Voltage Regulators

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Economical Inductrol voltage regulators precisely control (within ±1%) a-c voltage, help assure proper tube operation. This means longer tube life, less downtime, more efficient operation.

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*General Electric Trade-mark for induction voltage regulators.

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	I.D.	O.D.	Strip Width	I.D.	O.D.	H		I.D.	O.D.	Strip Width	I.D.	O.D.	H
47	.500	.625	.125	.440	.685	.195	75	1.250	2.000	.375	1.170	2.110	.445
2	.500	.750	.125	.440	.820	.195	15	1.500	2.500	.500	1.400	2.600	.600
37	.625	1.000	.188	.570	1.085	.262	16	1.625	2.000	.250	1.525	2.110	.330
3	.625	1.000	.250	.570	1.085	.340	17	2.000	2.500	.500	1.860	2.652	.610
5	.650	.900	.125	.585	.975	.195	58	2.000	3.000	1.000	1.860	3.152	1.188
79	.750	1.000	.250	.665	1.085	.340	76	2.000	3.000	.500	1.900	3.100	.610
7	.750	1.125	.188	.665	1.215	.262	18	2.500	3.000	.500	2.360	3.152	.610
9	1.000	1.250	.125	.915	1.340	.195	19	2.500	3.500	.500	2.313	3.688	.688
30	1.000	1.250	.250	.915	1.340	.320	20	2.500	3.500	1.000	2.313	3.688	1.188
10	1.000	1.375	.250	.925	1.455	.320	21	2.500	3.750	1.250	2.313	3.938	1.438
39	1.000	1.500	.250	.925	1.570	.320	22	2.500	3.750	1.500	2.313	3.938	1.688
62	1.000	1.500	.500	.925	1.570	.610	23	3.250	4.500	1.500	3.062	4.688	1.688
11	1.000	1.500	.375	.925	1.570	.445	77	3.250	5.000	1.500	3.062	5.188	1.688
13	1.250	1.750	.250	1.170	1.820	.330	25	4.000	5.250	2.000	3.813	5.438	2.188
29	1.250	1.750	.500	1.170	1.820	.610	78	4.000	6.000	2.000	3.813	6.188	2.188

MAGNETIC METALS COMPANY

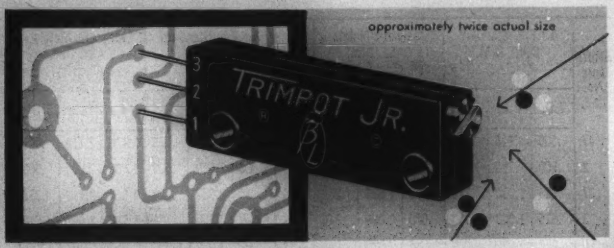
Hayes Avenue at 21st Street, Camden, N.J.

Electromagnetic Cores and Shields

Bourns NEW TRIMPOT JR.*

- micro-miniature size
- high power rating
- humidity proof

*Trade Mark



This micro-miniature potentiometer is designed for use with printed circuit boards and modular-type assemblies, and is derived from Bourns' original TRIMPOT.® The new TRIMPOT JR. is only 3/16" x 5/16" x 1" in size. Seventeen units can be mounted in one square inch of panel space. Power rating is 2 watts, and maximum operating temperature is 175°C.

The TRIMPOT JR. is built to meet or exceed government specifications for humidity, salt spray, vibration, acceleration, and shock. This potentiometer features a 15-turn screwdriver adjustment and 1½", 0.016" diameter leads. The shaft-clutch assembly idles when the mechanical limits are reached, thus preventing possible damage from forcing of adjustments. The TRIMPOT JR. is mounted with 2-56 screws through stainless steel eyelets on ¾" centers.

Deliveries from stock. Send for complete data: Bulletin JR.

BOURNS LABORATORIES, INC.

General Offices: 6135 Magnolia Avenue Riverside, California
Plants: Riverside, California—Ames, Iowa

TRIMPOT • LINEAR MOTION POTENTIOMETERS • PRESSURE TRANSDUCERS AND ACCELEROMETERS

(Continued from page 24A)

New Products

Type S Rack. Most effective in heavy manhole, vault, and shaft installations as a support for cable is the type *S* rack manufactured by T. J. Cope, Inc., 3rd and Walnut Sts., Collegeville, Pa. The arm will tilt to any angle of the cable and the coupling arrangement is designed to permit double racking. The uprights are made of 3-inch, 4.1-pound steel channel. Bolt holes are centered between each arm slot. The arms are cast from malleable iron and are easily removable without disturbing arms or cables above or below. Racks are available with from 2 to 6 holes in each arm. Overall rack lengths range from 1 foot, 4 inches to 3 feet, 4 inches with arms available from 5 inches to 18 inches long. Uprights and arms are available in hot galvanized finish. Porcelain supports are also furnished. The underlips hold them securely on the arm but at the same time permit perfect alignment with the cable.

High-Temperature Wire Kit. An engineer's evaluation kit containing 50 feet each of eight sizes and types of high temperature silicone rubber insulated wire has been announced by the Springfield Wire & Tinsel Co., Box 638, Springfield, Mass. The kit is designed for the use of those desiring an assortment of silicone wires for evaluation. It should also fill a

useful place in engineering laboratories, experimental and model shops. The temperature ratings are 150 C. and 200 C. Wire sizes include No. 14, No. 18, No. 20, No. 22, and No. 24, all with stranded copper conductors, two sizes silver plated, the others, tinned. Insulations include both 600- and 1,000-volt ratings. Three of the types have an outer glass braid, two have a dacron braid, and the rest are unbraided.

Atomic Powered Battery. No bigger than a cough drop, yet capable of providing usable electric current continuously for five years, this battery has been developed by Walter Kidde Nuclear Laboratories, Inc., 975 Stuart Ave., Garden City, L.I., N. Y., and Elgin National Watch Co., Electronics Division, Elgin, Ill. The battery is said to operate satisfactorily even over such extreme ranges of temperature

(Continued on page 35A)

(Continued from page 32A)

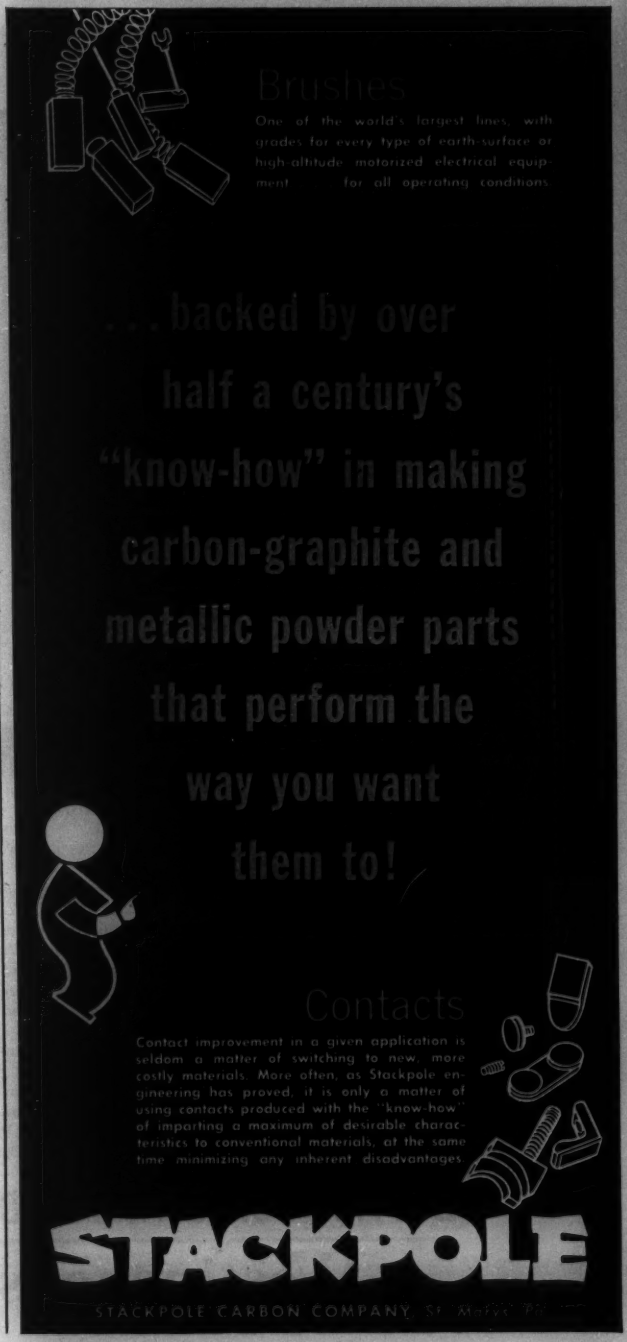
New Products

as 200 F below or above zero, unlike conventional batteries. The first such device to be completely safe for personal use without special precautions, the battery can be used to operate hearing aids, miniature portable radios and, the inventors predict, probably even wrist watches. Current is created in the battery by the impact of beta rays from radioactive promethium-147 on photoelectric cells. The promethium loses only about half its "power" in 2½ years.

Door Disconnect. An improved type *RAD* door disconnect having advanced design and construction features that assure greater safety, plus easier and faster installation and maintenance, has been announced by The Arrow-Hart & Hegeman Electric Co., Hartford, Conn. Among this improved *RAD* door disconnect's features which are cited by the manufacturer as promoting safety for personnel working on electrical control panels are visible contacts, a self-locating handle, and a line cover. With the contacts visible at all times when the door is open, the operator can see for himself whether the panel is electrically live or dead. The self-locating handle has an indicating line pointing to the operation location and the ON, OFF, and OPEN positions stand out clearly against a red background. A safety OFF feature is a locking ratchet which prevents accidental opening of the door, making it necessary to turn the handle manually to the OPEN position before the door can be opened. The line cover has testing holes through which test prods can be inserted to determine that the running line is dead, thus preventing accidental contact with live wires.

Oscilloscope Recording Camera. The Beattie Oscillotron Camera Recording System, model *K-5*, is extremely compact and is designed expressly to mount on all makes and types of portable and rack-mounted oscilloscopes, without interfering with the oscilloscope controls or other equipment in rack-mounted assemblies. Because of its compactness, it maintains minimum projection in front of the oscilloscopes. This system employs a basic periscope assembly which is provided with binocular viewing hood and port through which the image may be observed prior to, or during, operation. Interchangeable camera and magazine assemblies are available for attachment to the basic periscope assembly, including 35-mm and 70-mm film magazines for single-frame or continuous strip film operation, and Land-Polaroid cameras for rapid record reproduction. Time marking and data recording chambers are also available accessories. For more complete information regarding the Oscillotron Recorder, Model *K-5*, write to Photographic Products, Inc., 1000 No. Olive St., Anaheim, Calif.

(Continued on page 40A)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One of the world's largest lines, with grades for every type of earth-surface or high-altitude motorized electrical equipment . . . for all operating conditions.
. . . backed by over half a century's "know-how" in making carbon-graphite and metallic powder parts that perform the way you want them to!
Contacts
Contact improvement in a given application is seldom a matter of switching to new, more costly materials. More often, as Stackpole engineering has proved, it is only a matter of using contacts produced with the "know-how" of imparting a maximum of desirable characteristics to conventional materials, at the same time minimizing any inherent disadvantages.
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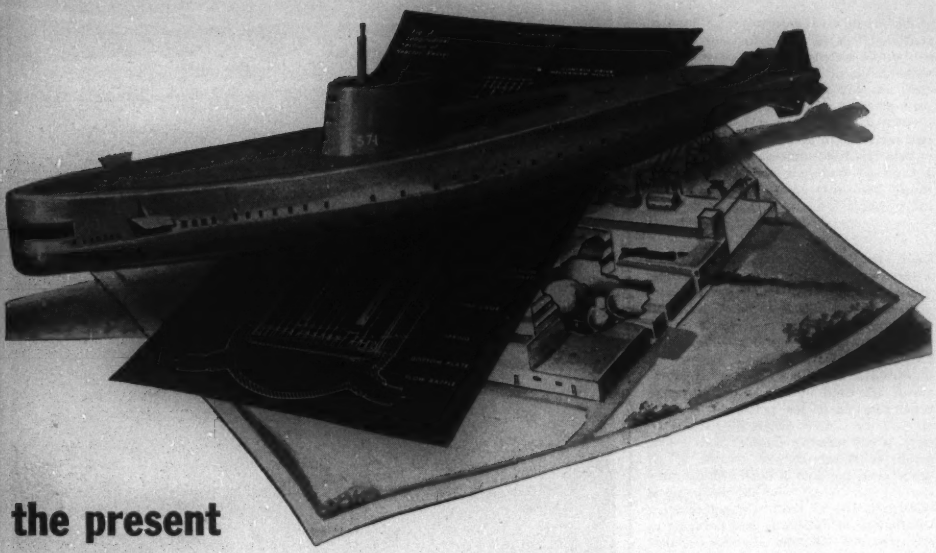
STACKPOLE CARBON COMPANY, St. Marys, Pa.



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If you are an outstanding young engineer looking toward a future in Atomic Power, you will be interested in our unique doctoral fellowship program.

The University of Pittsburgh and the Westinghouse Electric Corporation, in cooperation with the Atomic Energy Commission, offer an educational program that permits selected college graduates under a combination work-study program to earn a Doctor of Philosophy in electrical engineering with special opportunities for study in nuclear reactor engineering. In addition, the doctoral candidate will have a year's educational leave with a living allowance to prepare his doctoral dissertation.

At Bettis Plant engineers are investigating new areas for progress in all phases of reactor theory, design, and development. Here scientists and engineers have pioneered the first successful application of nuclear power, the USS *Nautilus* prototype. In 1957 the nation's first full-scale commercial generating plant at Shippingport, Pennsylvania, will have its turbines powered by a Westinghouse reactor.

ELECTRICAL ENGINEERS have excellent opportunities in the design and development of control systems involving servo-mechanisms and precision control elements. Other challenging areas include instrumentation and non-destructive testing of reactor fuel elements and components. Atomic experience is not required.

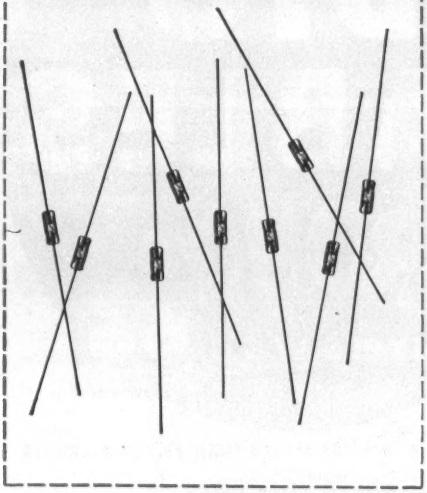
If you are interested in working in the expanding field of nuclear power, write today for a detailed brochure on our engineering fellowship program. Address your résumés to: Mr. M. J. Downey, Westinghouse Bettis Plant, Dept. A-161, P.O. Box 1468, Pittsburgh 30, Pennsylvania.

BETTIS ATOMIC POWER DIVISION

Westinghouse

HIGH CONDUCTANCE SILICON DIODES

Now, at Hughes, two new series



First, a high conductance series designed for operation up to 150°C and featuring forward conductance of at least 200mA at 1 volt, together with excellent reverse characteristics. Like all other Hughes diodes, these are packaged in our famous glass body for complete protection from contamination and moisture penetration. And like all other Hughes diodes, they conform to published specifications under a variety of operating conditions. Here, then, are specifications for representative types in the series.

	Max. DC Inverse Operating Voltage (volts)	Maximum Average Forward Current (mA) @25°C	@150°C	Maximum Forward Voltage @200mA @25°C (volts)	Inverse Current At Specified DC Test Voltage (μa) 25°C	150°C	Test Voltages (volts)
HD-6764	70	200	50	1.0	0.025	5	60
HD-6766	130	200	50	1.0	0.025	5	125
HD-6768	180	200	50	1.0	0.025	5	175
HD-6771	225	200	50	1.0	0.05	25	225
HD-6773	300	200	50	1.0	0.1	25	300
HD-6775	380	200	50	1.0	0.1	25	380

Second, a related high conductance series in the Hughes glass package with somewhat different characteristics.

	Comparable Competitive Types *	Max. DC Inverse Operating Voltage (volts)	Maximum Average Forward Current (mA) @25°C	@150°C	Maximum Forward Voltage @100mA @25°C (volts)	Inverse Current At Specified DC Test Voltage (μa.) 25°C	150°C	Test Voltages (Volts)
HD-6132	1N482B	36	200	50	1.0	0.025	5	30
HD-6133	1N483B	70	200	50	1.0	0.025	5	60
HD-6134	1N484B	130	200	50	1.0	0.025	5	125
HD-6135	1N485B	180	200	50	1.0	0.025	5	175
HD-6136	1N486A	225	200	50	1.0	0.05	25	225

*Currently these competitive types are not registered with RETMA; hence their specifications are subject to change. When they are registered, diodes now designated as HD types will be supplied as 1N types according to the registered specifications.

For details, please write: SEMICONDUCTOR DIVISION · HUGHES PRODUCTS
International Airport Station, Los Angeles 45, California

HUGHES PRODUCTS

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HUGHES
SEMICONDUCTORS

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TYPES W & G

NOW BEING MADE IN SIZES BIGGER THAN 1¾" IN DIAMETER

Write for new FREE catalog:

WESTERN INSULATED WIRE COMPANY

Los Angeles 58, California

(Continued from page 35A)

New Products

$1,000 Worth of Memory. Memory comes high these days, as is testified by the handful of stainless steel memory core bobbins for computers shown in the illustration. When wrapped with ⅛-mil (0.000125 inch) tape, and annealed, these bobbins will represent approximately $1,000 worth of cores for computers. Tape-wound cores on stainless steel bobbins have very rectangular hysteresis loops under pulse conditions, resulting in high values of residual magnetism. It is this characteristic of the

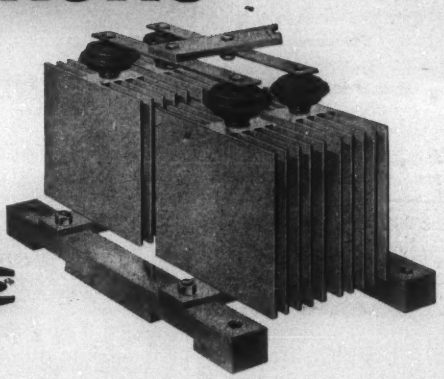
high permeability, ultrathin magnetic tape, along with the ability of the small core to switch from positive to negative saturation in a very few microseconds, which makes such cores suitable for use as memory cells for electronic computers. The use may be in the form of a shift register, a coincident-current matrix, a core-diode memory system, a harmonic generator, or a pulse transformer. It is manufactured by Magnetics, Inc., Butler, Pa.

High-Pressure Blower. A line of new and unusually designed multistage centrifugal blowers allows delivery of 25 to 350 cubic feet per minute (cfm) at static pressure of 10 to 55 inches water column (2 pounds per square inch) on suction or pressure. These blowers incorporate three to nine cascaded pressure stages. They have no wearing parts and are direct-coupled (no belts to a ¼- to 2-hp induction motor which is an integral part of the unit. The shaft speed of the blower being only 3,400 rpm, noise levels are relatively very low. The entire assembly runs on only two ball bearings. Integral airfilters and outlet manifolds are available in various configurations to suit individual project requirements. Motors are wound single or 3 phase and for all standard line voltages. The peculiar construction of the model *L* blowers results in small size and light weight as required by electronic, instrument, and computer applications. This unit was primarily designed for computer tape slack control. Catalog sheets No. *40302-1* and No. *40302-2* give complete dimensional and performance specifications. For further information contact Rotron Manufacturing Co., Schoonmaker Lane, Woodstock, N. Y.

(Continued on page 42A)

GENERAL ELECTRIC HIGH-CURRENT SILICON RECTIFIERS... NOW IN STACKS

Permits new highs in rectification efficiency with reduced space-weight-cost requirements



These new high-current rectifier stacks supply exceptionally long service without attention or maintenance. There are no moving parts, liquids, vapors, or sensitive electrodes involved. And the fin design provides adequate cooling in many applications without forced air.

The rectifying units proper are the famous 4JA60 Silicon high-current rectifiers produced by the General Electric alloy technique. Hermetically sealed in rugged metal housings, they are protected against damage from moisture, dust, fumes and corrosion.

Silicon high-current stacks are now available, completely assembled to meet your circuit requirements in stacks containing up to twelve rectifying elements. These compact, easily installed stacks may be the answer to your present design problems of big capacity in small space.

TYPICAL APPLICATION...GENERAL ELECTRIC 4JA6011 SILICON HIGH-CURRENT RECTIFIER STACK

CIRCUIT	Three Phase Bridge Rectifier, Resistive Load.
DC OUTPUT	280 volts, 250 amperes, 70 kilowatts.
RECTIFIER LOSSES	Approximately one percent (¾ kw).
COOLING REQUIRED	35°C Free air. Forced air may be used for additional current if desired.
VOLUME	Total volume of assembly—less than ½ cubic foot.

Your General Electric representative will be glad to supply full data. Or, write to *General Electric Company, Semiconductor Products, Section S1857, Electronics Park, Syracuse, New York.*

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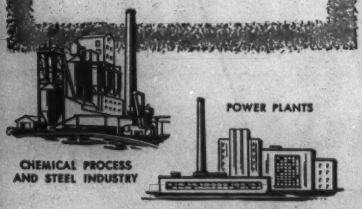

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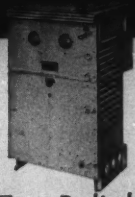

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Over a Quarter Century of Rectifier Manufacturing

(Continued from page 40A)

TRADE LITERATURE

Aircomatic Cutting. Development and applications of aircomatic cutting, a new method for straight line and shape cutting of nonferrous metals, are described in detail in a 24-page informational pamphlet and catalog released by the Air Reduction Sales Company, a Division of Air Reduction Company, Inc. The method, which employs standard Aircomatic[R] welding equipment for manual and machine cutting, is particularly applicable for high-speed cutting and shaping of plates and parts to be joined by gas-shielded arc welding. The cut edges produced usually require no further processing prior to welding. While the majority of applications of the cutting process to date have involved aluminum and stainless steel, success has also been achieved with chrome steels, nickel, Monel, Inconel, copper, brass, and aluminum bronze. Severance cuts have also been made in titanium and magnesium. Copies of the new piece of literature containing information on the process can be obtained by writing to Air Reduction Sales Company, 150 E. 42nd St., New York 17, N.Y. Request form *ADE 880*.

Floodlighting Catalog. An illustrated catalog issued by Stonco Electric Products Company, Kenilworth, N. J., condenses their entire cast aluminum floodlighting line into 48 pages. Twelve pages are taken up with cast aluminum vaportight pendant, ceiling, and wall fixtures; 8 pages with wiring troughs, splice boxes, and other outdoor fittings; and 17 pages with the popular sealed-beam floodlighting lampholders. Complete lighting performance tables are included for the new high efficiency long-throw *PAR-46*, *PAR-56*, and *PAR-64* 500-watt power-beam projector lamps in narrow spot, medium, and wide flood. A complete new "Homelight" line for garden and residential use including portable spike lights, wall lights, and clamp lights has been included. Catalog *156* with the consolidated price line brought up to date can be had by writing the manufacturers.

Pump-Turbine Film. "Captive Kilowatts," a 16-mm color-sound movie describing the reversible pump–turbine and its use to level system load curves is now available from Allis-Chalmers for showing before engineering groups. Running 17 minutes, "Captive Kilowatts" tells how pump–turbines function to help utilities pursue more effectively their long-established policy of providing h mes, commercial enterprises, and industries with vast quantities of never-failing economical electric power. Requests for prints of "Captive Kilowatts" should be made to the nearest Allis-Chalmers Industries Group sales office or to the company's advertising and industrial press department, Milwaukee 1, Wis.

(Continued on page 44A)

Wire Sculpture by Henry Szafarz

It's Another World . . .

one in which the forces of nature are extremely rough on man-made things. Thus, the simple fact that Simplex supplies more submarine cable than all other manufacturers combined speaks volumes as to product quality. Simplex Submarine Cables are specifically engineered for reliable underwater communication and power transmission. Their many varieties of outer coverings, wire armor, heavy jackets of Neoprene and other materials, guard against underwater hazards and assure long, dependable service.

SIMPLEX WIRE & CABLE CO.,
79 Sidney Street,
Cambridge 39, Mass.

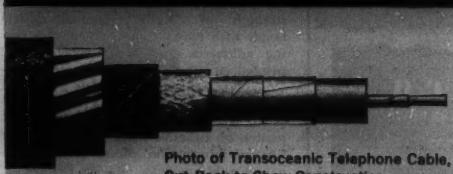

Photo of Transoceanic Telephone Cable, Cut Back to Show Construction

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APPLICATIONS

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Electrical Communication Systems (Selective Calling)
Remote Operation and Supervisory Control of Machinery and Apparatus
Electrical Computers and Telemetering Systems
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Frahm Oscillator Controls, Type ROC, make possible the design and construction of inexpensive, precision tone generators that are small and light weight. These generators will have accurate output frequency and output voltage with very nearly sinusoidal wave shape.

They can be made with any one nominal control frequency between 20 and 1100 cps. They will control the output frequency of circuits, under specified conditions, constant within ±0.15% of the nominal control frequency.

We particularly encourage your inquiries and correspondence on special applications and problems. If you haven't explored these Frahm Oscillator Controls we'll be glad to send you complete specifications, characteristics, etc. Write for Bulletin 34-EE.

B-706

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(Continued from page 42A)

Trade Literature

Ink for Insulation. A line of printing inks especially developed for permanent printing on Teflon insulated wires and cables has been introduced by Hitemp Wires, Inc. This newly developed ink features the same excellent characteristics as Teflon itself, that is once printed on Teflon insulation it will give 100% adherence under the following severe service conditions: completely unaffected by extreme temperatures (−90C to +250C) and inert to all known commercial solvents and chemicals. The ink can be applied with the same standard, engraved wheel-type, printink equipment as is currently used to print on Vinyl. However, after leaving the printing equipment the ink must be cured at a temperature of 650F. Because the dwell time of the curing can be short, the total operation can remain continuous by passing the printed Teflon wire or cable through a 650F oven as it comes from the printing wheels. Hitemp ink is currently available in quantities of 8 ounces or more. At present the new ink is available only in black; however, it is anticipated that a wide variety of colors will be available soon. For further information write G. D. Newman, Jr., National Sales Manager, Hitemp Wires, Inc., 26 Windsor Ave., Mineola, N.Y.

Aircraft Equipment Booklet. "Profiles in Progress," an illustrated booklet on the vital part played by highly specialized aircraft equipment in the jet age, has been issued by Hamilton Standard, Division of United Aircraft Corporation, Windsor Locks, Conn. It discusses, in layman's language, aircraft air-conditioning systems, turbine engine starters, fuel controls, hydraulic pumps, pneumatic valves, and electronic temperature controls. The booklet has the most complete list yet published of the jet aircraft using Hamilton Standard equipment, together with the list of the equipment used on each aircraft.

Adhesives and Plastics. An 8-page reprint of a technical paper, "Use of Adhesives with Reinforced Plastics," originally presented before the Reinforced Plastics Division of The Society of the Plastics Industry, Inc. (SPI), is available in booklet form on request from Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N.J. The illustrated booklet, amply supported by tables, charts, and diagrams, contains data on effect of temperature on tensile shear strengths, physical properties of foamed-in-place plastic sandwiches, peel strength of "Kel-F" laminate-to-steel bonds with epoxy room temperature curing adhesives, and bond properties of printed circuit laminates made with various adhesives. Included also is a detailed bibliography containing many helpful reference sources for further technical information on adhesive usage and testing. For further information please contact Bernard Gould, manager, Market Devices.